A

Abelite An explosive, composed mainly of ammonium nitrate and trinitrotoluene.

Absolute Zero The least possible temperature for all substances. Generally accepted as -273.15ÝC

AC Alternating current.

Acceptance Quality Level (AQL) A nominal value expressed in terms of percentage defective per hundred units, by which a group of sampling plans is identified. The sampling plans so identified have a high probability of accepting lots containing material with a process average not greater than the designed value of the AQL.

Acetin [CH3COOC3H5(OH)2] also known as glyceryl monoacetate, a colourless hydroscopic liquid. Used as an intermediate for various explosives, and a solvent for various dyes.

Acetone [CH3COCH3] colourless, flammable liquid. Acetone is widely used in industry as a solvent for many organic substances. It is used in making synthetic Resins and fillers, smokeless powders, and many other organic compounds. Boiling Point 56ÝC. Useful solvent for acetylene, also known as the simplest saturated ketone.

Acetylene or ethyne, a colourless gas and the simplest alkyne Hydrocarbon. Explosive on contact with air, it is stored dissolved under pressure in Acetone. It is used to make neoprene rubber, plastics, and resins. The oxyacetylene torch mixes and burns oxygen and acetylene to produce a very hot flame-as high as 3480ÝC (6300ÝF)-that can cut steel and weld iron and other metals. Produced by the action of wateron calcium carbide and catalytically from naphtha.

Acetylide A carbide formed by bubbling acetylene through a metallic salt solution, eg cuprous acetylide, **Cu2C2**. These are violently explosive compounds.

Acid Any substance capable of giving up a proton; a substance that ionizes in solution to give the positive ion of the solvent; a solution with a pH measurement less than 7.

Acidity the quantitative capacity of aqueous solutions to react with hydroxyl ions. It is measured by titration with a standard solution of base to a specified end point.

Acids & Bases are two related classes of chemicals; the members of each class have a number of common properties when dissolved in a solvent, usually water. Acids in water solutions exhibit the following common properties: they taste sour; turn litmus paper red; and react with certain metals, such as zinc, to yield hydrogen gas. Bases in water solutions exhibit these common properties: they taste bitter; turn litmus paper blue; and feel slippery. When a water solution of acid is mixed with a water solution of base, a salt and water are formed; this process, called neutralisation, is complete only if the resulting solution has neither acidic nor basic properties. When an acid or base dissolves in water, a certain percentage of the acid or base particles will break up, or dissociate, into oppositely charged ions. The Arrhenius theory of acids and bases defines an acid as a compound that can dissociate in water to yield hydrogen ions (H+) and a base as a compound that can dissociate in water to yield hydroxyl ions (OH-). The Brönsted-Lowry theory defines an acid as a proton donor and a base as a proton acceptor. The Lewis theory defines an acid as a compound that can accept a pair of electrons and a base as a compound that can donate a pair of electrons. Each of the three theories has its own advantages and disadvantages; each is useful under certain conditions. Strong acids,

such as hydrochloric acid, and strong bases, such as potassium hydroxide, have a great tendency to dissociate in water and are completely ionised in solution. Weak acids, such as acetic acid, and weak bases, such as ammonia, are reluctant to dissociate in water and are only partially ionised in solution. Strong acids and strong bases make very good Electrolytes (see Electrolysis), i.e., their solutions readily conduct electricity. Weak acids and weak bases make poor electrolytes.

Acne Spots A useful visual aid that youthful pimple-spotted adolescents are very likely under the age of 18 and therefore not legally able to purchase fireworks. All shopkeepers should be on the look-out for all customers with inflammation of the sebaceous glands.

Accroid Resin Also known as red gum. A natural plant extract used as a binder and/or a fuel in lots of pyrotechnic compositions*. See Gums.*

Actinide Series The radioactive metals, with atomic numbers 89 through 103, in group IIIb of the periodic table. They are Actinium, Thorium, Protactinium, Uranium, Neptunium, Plutonium, Americium, Curium, Berkelium, Californium, Einsteinium, Fermium, Mendelevium, Nobelium, and Lawrencium. All members of the series have chemical properties similar to actinium. Those elements with atomic numbers greater than 92 are called Transuranium Elements.

Activation treatment of a substance by heat, radiation, or activating reagent to produce a more complete or rapid chemical or physical change.

Acyclic Compound An organic compound with molecules which have carbon atoms arranged in open chains as opposed to closed chains.

Additive Something added to a basic composition to accomplish some special purpose - mostly in small proportions.

Adhesion and cohesion, attractive forces between material bodies. Adhesive forces act between different substances, whereas cohesive forces act within a single substance, holding its atoms, ions, or molecules together. Without these forces, solids and liquids would act as gases. Surface Tension in liquids results from cohesion, and Capillarity results from a combination of adhesion and cohesion. Friction between two solid bodies depends in part on adhesion.

Adiabatic Occurring without gain or loss of heat; a change of the properties, such as volume and pressure of the contents of an enclosure, without exchange of heat between the enclosures and its surroundings.
Adiabatic Flame Temperature As applied to interior ballistics calculation, the temperature that the gaseous products of combustion of the propellant would attain if maintained at constant volume and without loss of energy to the surrounding medium.

Adiabatic Temperature The temperature attained by a system undergoing a volume or pressure change in which no heat enters or leaves the system.

Adsorption The adhesion of an extremely thin layer solid, liquid, or vapour molecules to the surface of a solid or liquid.

Aerial firework generally a firework which functions in the air/sky i.e. rockets, shells, roman candles and mines.

Aerial shell *Material to be added later*

Aerobic Living or occurring only in the presence of oxygen.

Aerosol A mixture of extremely fine liquid or solid particles (colloidal system) and a gas or air such as smokes or fog.

Agglomeration The property of particles to cohere, thereby increasing apparent particle size.

Air Blast, *Mil.* The airborne shock wave or acoustic transient generated by an explosion.

Air Burst, *Fwk.* A burst of a projectile or bomb above the ground.

Alcohol is a class of organic compounds with the general formula R-OH, where R is an alkyl group made up of carbon and hydrogen and -OH is one or more hydroxyl groups, each made up of one atom of oxygen and one of hydrogen. Generally, with fireworks, the term is applied to ethyl alcohol **[C2H5OH]**. Although the term alcohol often refers to Ethanol, the alcohol in alcoholic beverages, the class of alcohol also includes Methanol and the amyl, butyl, and propyl alcohols, all with one hydroxyl group; the glycols, with two hydroxyl groups; and glycerol, with three. Many of the characteristic properties and reactions of alcohols are due to the polarity, or unequal distribution, of electric charges in the C-O-H portion of the molecule.

Alizarin [C14H6O2(OH)2] also known as 1,2-dihydroxyanthraquinone. Red prism crystals or needles, melting point 289ÝC. One of the most important natural and synthetic dyes, which can also be nitrated.

Alkali Metals are elements in group Ia of the Periodic Table. In order of increasing atomic number, they are Lithium, Sodium, Potassium, Rubidium, Caesium, and Francium. They are softer than other metals, and have lower melting points and densities. All react violently with water, releasing hydrogen and forming hydroxides. They tarnish rapidly, even in dry air. They never occur uncombined in nature.

Alkali, Hydroxide of an Alkali Metal. Alkalies are soluble in water and form strongly basic solutions. They neutralize acids, forming salts and water. Strong alkalies (e.g., those of sodium or potassium) are called caustic alkalies.

Alkaline-Earth Metals are elements in group IIa of the Periodic Table. In order of increasing atomic number, they are Beryllium, Magnesium, Calcium, Strontium, Barium, and Radium. They are softer than most other metals and react readily with water. Their properties are exceeded by the corresponding Alkali Metal.

Alkalinity the capacity of water to neutralize acids, a property imparted by the water's content of carbonate, bicarbonate, hydroxide, and on occasion borate, silicate, and phosphate. It is expressed in milligrams per litre of equivalent calcium carbonate (mg/l CaCO3).

All-Fire Current The minimum amperage (or wattage) level, which must be applied to a bridge wire circuit to reliably, ignite the surrounding explosive material without regard to the time of operation. Operation at all-fire level should be avoided.

Allotropy The occurrence of certain chemical elements in two or more forms; the forms are called allotropes. Allotropes generally differ in physical properties, such as colour and hardness; they may also differ in molecular structure or in chemical activity but are usually alike in most chemical properties. Diamond and Graphite are two allotropes of the element Carbon.

Alloy A combination, usually of 2 or more metals, which takes on some of the characteristics of its components. Alloys cannot be separated into their constituent parts by normal physical methods.

Alternating current (ac) current that reverses its direction at regular intervals, such as a common 240 volt circuit.

Alum technically, a double sulphate of ammonium or a univalent or trivalent metal but commonly used to denote aluminium sulphate [Al2(SO4)3]

Aluminised Explosive A high explosive to which aluminium powder or flake has been added.

Aluminium [Al] There are numerous physical forms of aluminium used in the manufacture of fireworks. Powders can be produced in hammer mills, ball mills forming types of 'flake', or by atomisation, which forms 'spherical particles', Large flake aluminium is known as "Flitter", while the smaller flakes are known as "Fine Bright" or "Bright", these both are a bright silver in appearance and feel greasy to the touch. These flakes are formed by stamping with a lubricant (stearic acid), and producing small flat plates of foil-like particles, of irregular shape with a large surface area. Another variety of flake is called Dark Pyro, which is very fine (Mesh size 200), this is a dull dark grey in appearance, possibly due to up to 2% of carbon it often contains. In Germany the term Bronze and Flitter are used as is the term 'schliff' for flake and 'pyroschliff' for very fine flakes, brand names include "Black Head", "Blue Head" and "Gloria".

Aluminium Chloride [AlCl3] This chemical must not come in contact with the skin as severe burns can result. The yellowish-white crystals or powder have a strong attraction for water.

Aluminium Oxide, hydrated [Al2O3] Used in old-fashioned firework end plug glue formulations.

Aluminium, atomised Spherical in appearance. Used in glitter formulations. Sometimes coated with (Dupont Viton A) vinylidene fluoride or hexafluoropropylene copolymer.

Amatol High explosive made of a mixture of ammonium nitrate and trinitrotoluene; sometimes used as a bursting charge in high-explosive projectiles.

Amber Powder (*Konroku*) This is a fossil resin of vegetable origin and is yellowish-brown in colour. It is sometimes used in fireworks in a powdered form as a fuel. A rich source of Succinic acid.

Ambient Surrounding meteorological conditions such as ambient temperature, humidity and pressure.

Amines a class of organic compounds of nitrogen that may be considered as derived from ammonia (NH3) by replacing one or more of the hydrogen atoms by organic radicals, such as CH3 or C6H5, as in methylamine and aniline. The former is a gas at ordinary temperature and pressure, but other amines are liquids or solids. All amines are basic in nature and usually combine readily with hydrochloric or other strong acids to form salts.

Ammine An inorganic compound containing NH3 molecules as part of a complex salt or coordination compound. (Example: hexamine cobalt (III) nitrate; also spelled hexamine.)

Ammonia [NH3] is a chemical compound, colourless gas with a characteristic pungent, penetrating odour. It is extremely soluble in water. Ammonia solutions are used to clean, bleach, and deodourize; to etch aluminium; to saponify oils and fats; and in chemical manufacture. Ammonia and ammonia vapours are irritating-prolonged exposure and inhalation cause serious injury and may be fatal. Water-free ammonia is used in refrigeration. The major use of ammonia and its compounds is as Fertilizers. Ammonia is

usually produced by direct combination of nitrogen with hydrogen at high temperature and pressure in the presence of a catalyst.

Ammonium Bichromate (Dichromate) **[(NH4)2CrO7]** available as orange crystals. Used in the manufacture of indoor tabletop volcanoes (known as Vesuvius Fire) and occasionally used in smoke formulas.

Ammonium Chloride [NH4Cl] The common name is sal ammoniac. Comes as colourless crystals or a white powder. Used to manufacture safety explosives and white smokes.

Ammonium Dichromate [(NH4)2Cr2O4] Orange granular. Oxidizer used in volcanoes, sometimes used as a burn rate catalyst in propellant formulas (such as those based on ammonium nitrate).

Ammonium Dihydroxide Phosphate Piezo-electric crystal used in numerous transducers.

Ammonium Nitrate [NH4NO3] The ammonium salt of nitric acid.

Ammonium Nitrate Satchel Charge A mixture of ammonium nitrate fertilizer and melted wax. The mixing ratio is 4 : 1 wax.

Ammonium Oxalate [(NH4)2C2O4.H2O] takes the form of colourless, poisonous, crystals. Used in the manufacture of safety explosives.**Ammonium Perchlorate [NH4ClO4]** A white crystalline powder (rhombic crystals), ideally about 120mesh. As an oxidising agent, which has got no base flame colour, it is particularly useful in the production of rich colours, particularly red and blues. Should not be used in mixes containing chlorates or come into intimate contact with chlorate-based stars in mines or rockets, etc. Used in strobe, colour and rocket propellant formulations. Oxidizer used in strobe compositions; produces rich colours in some star and fountain formulations, but slow burning; most commonly used composite rocket fuel oxidizer.

Ammonium Permanganate [NH4MnO4] A moderate explosive which can be detonated by either heat or shock.

Ammonium Picrate [NH4C6H3O7] These bright orange crystals are used in armour piercing shells and occasionally in fireworks. If heated to 300 degrees it will explode or it can be set off by shock. If you do any work with this chemical, it is advisable to keep it wet.

Ammonium salts Due to the possible formation of the highly unstable and explosive ammonium chlorate through ion exchange, modern day practise excludes their use in fireworks except perchlorates.

Ammonol High-explosive substance made of a mixture of ammonium nitrate, trinitrotoluene, and flaked or powdered aluminium. Ammonal is sometimes used as a bursting charge in high-explosive projectiles, and produces bright flashes on detonation.

Ammunition All components and any explosives case or contrivance prepared to form a charge, complete round, or cartridge for cannon, howitzer, mortar, or small arms, or for any other weapon, torpedo warhead, mine, depth charge, demolition charge, fuse, detonator, projectile, grenade, guided missile, rocket, pyrotechnics; and all chemical agents, fillers and associated hazardous materials.Ordnance means, in addition, also non-offensive military items. Munitions(s) equals ordnance. Ammunition with primer and propellant powder contained in a cartridge case permanently crimped or attached to a projectile. Loaded into a weapon as a unit. Usually termed "cartridge."

Amorphous term describing a material without the periodic, ordered structure of crystalline solids.

Ampere A unit of electrical current produced by 1 volt acting through a resistance of 1 ohm. Also referred to as an "amp" or "amps".

Amyloid A starch-like cellulose compound.

AN Ammonium nitrate.

AN slurry Ammonium Nitrate Slurry.

AN/FO A commercial blasting agent consisting of AN and fuel oil.

Anaerobic refers to living or occurring only in the absence of free oxygen.

Analysis A branch of mathematics that uses the concepts and methods of the Calculus. It includes basic calculus; advanced calculus, in which such underlying concepts as that of a Limit are subjected to rigorous examination; differential and integral equations, in which the unknowns are functions rather than numbers; Vector and tensor analysis; differential geometry; and many other fields.

Angle Iron Mild steel bar in an L-shaped cross-section which is often used to manufacture Mortar racks.

Angstrom a unit of length, used especially in expressing the length of light waves, equal to one ten-thousandth of a micron, or one hundredth-millionth of a centimetre (1 x 10E-8 cm).

Anhydrous refers to a term meaning without water or combined water i.e. water of crystallization.

Aniline Dyes These are used in smoke powder formulas. They are organic coal tar derivatives. Available in many different colours.

Aniline Green [C23H25CIN2] Also known as Malachite Green. One of the many Aniline dyes. The green crystals are used in smoke formulas.

Anion is an ion having a negative charge; an atom with extra electrons. Atoms of non-metals, in solution, become anions.

Annealing A heat treatment process intended to bring about a soft, stress-free state in worked materials. Heating to a temperature so that diffusion and stress relaxation can occur and then cooling slowly to minimize thermal gradients, through differential thermal contraction.

Anode The positive pole of a direct current device. Opposite of Cathode (adj.: anodic).

Anthrence [C12H10] Generally supplied as a greeny/yellow lumpy powder, from the distillation of coal tar, but the pure form of powder is a fine blue fluorescent colour. Used mainly in the use of black smokes. Melting Point at 217ÝC, Boiling Point 340ÝC.

Anthraquinone [C6H4(CO)2C6H4] Also known as Diphenylene diketone, yellow needle-like or prism crystals, melting point 285ÝC and boiling point 382ÝC. More like diketones than quinones.Parent substance of the group of dyes, which includes alizarin. Sublimes very easily.

Antifreeze is a substance added to a solvent to lower its freezing point. Antifreeze is typically added to water in the cooling system of internal combustion engines so that it may be cooled below the freezing point of pure water (32Ý F or 0Ý C) without freezing. Automotive antifreezes include ethylene glycol (the most widely used), methanol, ethanol, isopropyl alcohol, and propylene glycol. A 35% solution will not freeze at temperatures above -20ÝC. WARNING: Straight antifreeze can be deflagrated and / or be very flammable if directly exposed to a high explosive detonation.

Antimatter Material composed of antiparticles, which correspond to ordinary protons, electrons, and neutrons but have the opposite electrical charge and magnetic moment. When matter and antimatter collide, both may be annihilated, and other Elementary Particles, such as photons and pions, are produced. In 1932 Carl D. Anderson, while studying cosmic rays, discovered the positron, or antielectron, the first known antiparticle. Any antimatter in our part of the universe is necessarily very short-lived because of the overwhelming preponderance of ordinary matter, by which the antimatter is quickly annihilated.

Antimony [Sb] A dark grey powder usually about 240 mesh, melting point 630ÝC. Also known as Antimony Regulus, found in nature as stibnite. Used in white fire compositions, but mainly used in mixes containing gunpowder and aluminium to produce the "glitter effect". Antimony reacts less violently with oxygen than either aluminium or magnesium.

Antimony Disulphide [Sb2S3] Dark grey, sparkly powder. Fuel used in glitter compositions and commonly in white comets and stars. Fuel is sometimes used to increase sensitivity of flash powder. See Antimony Sulphide.

Antimony Fulminate One of a group of unstable, explosive compounds related to Mercury Fulminate.

Antimony Potassium Tartrate Also known under the name of Tartar Emetic. These poisonous, transparent crystals or white powder, are used to make Antimony Fulminate. Any moisture present can be driven off by heating to 100ÝC but above this and the chemical will decompose.

Antimony Sulphide [Sb2S3] This has usefulness in sharpening the report of firecrackers, salutes, etc. or to add colour to a fire.

Antimony Trisulphide Dirty black powder usually about 200mesh (there is also a red precipited form).Also known native ore, Stibnite. Similar in use to the metal powder although ignites easier. Synthetically produced material is crap.

Apparent Density The ratio of mass to volume of a finely powdered material, under stated conditions, which is always less than true density. Sometimes called loading density. Because apparent density depends on the method used to obtain it, the method should always be specified. Bulk Density.

Approved or approval Means sanctioned, endorsed, accredited, certified, or accepted as satisfactory by a duly constituted and nationally recognized authority or agency.

Aqua Fortis Old fashioned term for concentrated Nitric acid.

Aqua Regia A strong acid containing 1 part concentrated Nitric Acid and 3 parts concentrated Hydrochloric Acid. Store in a well closed glass bottle in a dark place. This acid will attack all metals, including gold and platinum. It is used in making some explosives.

Aqueous In fireworks, aqueous usually refers to solutions used for damping stars in manufacture.

Aquifer a subsurface geological structure that contains water.

Arachis Oil Peanut oil.

Archimedes 'Principle of Archimedes' states that a force equal to the weight of the displaced fluid buoys up a body immersed in a fluid. The principle applies to both floating and submerged bodies, and to all fluids. It explains not only the buoyancy of ships but also the rise of a helium-filled balloon and the apparent loss of weight of objects underwater.

Argon [Ar] gaseous element, discovered in 1894 by Sir William Ramsay and Lord Rayleigh. An odourless, tasteless, and colourless inert gas, it makes up 0.93% of the atmosphere by volume. Argon is used in light bulbs and neon signs, in refining reactive elements, and for protection in arc welding.

Argillaceous Rocks Sediments of silts or clay. Common minerals are kaolinite and montmorillonite.

Arming as applied to fuses, the changes from a safe condition to a state of readiness for initiation. Generally a fuse is caused to arm by acceleration, rotation, clock mechanism or air travel, or by combinations of these.

Aromatic Compound is any of a large class of organic compounds including Benzene and compounds that resemble benzene in chemical properties. Aromatic compounds contain unusually stable ring structures, often made up of six carbon atoms arranged hexagonally. Some of the compounds, however, have rings with more or fewer atoms, not necessarily all carbon. Furan, for example, has a ring with four atoms of carbon and one of oxygen. Also, two or more rings can be fused, as in naphthalene. The characteristic properties of the class, notably the stability of the compounds, derive from the fact that aromatic rings permit the sharing of some electrons by all the atoms of the ring, which increases the strength of the bonds.

Arsenic Disulphide [As2S2] A red/orange fine powder, also known as realgar. Has been used in making white fires and smokes very limited use in modern day compositions.

Arsenic Sulphide, Yellow [As2S3] This Chemical is just as poisonous as its red brother and is also used in fireworks, somewhat. The common name is Kings Gold.

Arsenic Trisulphide Two forms a red and yellow powder, also known as Orpiment. The yellow form turns red at 170C. Used in easily ignited white stars and some smoke compositions. Used with Lampblack to produce the wonderful golden spur like effect of the traditional Flower Pot.

Arsenious Oxide [As4O6] A white, highly poisonous powder used in fireworks. It is also known as Arsenic Trioxide, Arsenious Oxide and Arsenous Acid. Its uses are similar to Paris Green.

Artillery is a term now applied to heavy firearms, as distinguished from Small Arms. Modern artillery includes a variety of long-range guns that fire their shells with rapid muzzle-velocity in a low arc; howitzers, which fire on a high trajectory at relatively nearby targets; antiaircraft guns, which fire rapidly and at high angles; armour-piercing anti-tank guns; and many field-artillery pieces used in support of infantry and other ground operations.

Asphalt A blackish brown lumpy powder, also known as Gilsonite and Asphaltum. Difficult to keep in powder form and has very limited uses. Very dirty to work with, also very sticky.

Asphaltum Also known as gilsonite and asphalt. Sometimes used as a substitute for carbon as a fuel. A black bituminous substance, best described as powdered tar.

Astronomical Unit (AU) means distance between the earth and the sun. One AU is @92,960,000 miles or 149,604,970 km.

Atmosphere The envelope of air surrounding the earth; also, the body of gases surrounding or comprising any planet or other celestial body. Atmospheric pressure may be measured as weight per area. On earth, normal air pressure at sea level is 14.7 pounds of weight per square inch, or 1033 grams of weight per square centimetre.

Atom The atom is the smallest unit of a chemical Element having the properties of that element. An atom contains several kinds of particles. Its central core, the nucleus, consists of positively charged particles, called Protons, and uncharged particles, called Neutrons. Surrounding the nucleus and orbiting it are negatively charged particles, called Electrons. Each atom has an equal number of protons and electrons. The nucleus occupies only a tiny fraction of an atom's volume but contains almost all of its mass. Electrons in the outermost orbits determine the atom's chemical and electrical properties. The number of protons in an atom's nucleus is called the Atomic Number. All atoms of an element have the same atomic number and differ in atomic number from atoms of other elements. The total number of protons and neutrons combined is the atom's Mass Number. Atoms containing the same number of protons but different numbers of neutrons are different forms, or Isotopes, of the same element.

Atomic absorption quantitative chemical method used for the analysis of elemental constituents.

Atomic Bomb A weapon deriving its great explosive force from the sudden release of Nuclear Energy through the fission, or splitting, of heavy atomic nuclei. Practical fissionable nuclei for atomic bombs are the isotopes Uranium-235 andPlutonium-239, which are capable of undergoing chain reaction. If the mass of the fissionable material exceeds the critical mass, the chain reaction multiplies rapidly into an uncontrollable release of energy. An atomic bomb is detonated, by bringing together, very rapidly (e.g., by means of a chemical explosion) two sub critical masses of fissionable material. The ensuing explosion produces great amounts of heat, a shock wave, and intense neutron and gamma radiation. The region of the explosion becomes radioactively contaminated, and wind-borne radioactive products may be deposited elsewhere as fallout.

Atomic mass - unit (amu) a unit of mass equal to 1/12 the mass of the carbon isotope with mass number 12, approximately 1.6604 x 10E-24 gram.

Atomic Number Often represented by the symbol Z, the number of Protons in the nucleus of an Atom. Atoms with the same atomic number make up a chemical Element. The elements are arranged in the Periodic Table in the order of their atomic numbers. Atomic Weight Mean (weighted average) of the masses of all the naturally occurring Isotopes of a chemical Element; the atomic mass is the mass of any individual isotope. Atomic weight is usually expressed in atomic mass units (amu); the atomic mass unit is defined as exactly 1/12 the mass of a carbon-12 atom. Each proton or neutron weighs about 1 amu, and thus the atomic mass is always very close to the Mass Number (total number of protons and neutrons in the nucleus). Because most naturally occurring elements have one principal isotope and only insignificant amounts of other isotopes.

Ammonium Nitrate [NH4NO3] The ammonium salt of nitric acid.

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Antifreeze is a substance added to a solvent to lower its freezing point. Antifreeze is typically added to water in the cooling system of internal combustion engines so that it may be cooled below the freezing point of pure water (32Ý F or 0Ý C) without freezing. Automotive antifreezes include ethylene glycol (the most widely used), methanol, ethanol, isopropyl alcohol, and propylene glycol. A 35% solution will not freeze at temperatures above -20ÝC. WARNING: Straight antifreeze can be deflagrated and / or be very flammable if directly exposed to a high explosive detonation.

Antimatter Material composed of antiparticles, which correspond to ordinary protons, electrons, and neutrons but have the opposite electrical charge and magnetic moment. When matter and antimatter collide, both may be annihilated, and other Elementary Particles, such as photons and pions, are produced. In 1932 Carl D. Anderson, while studying cosmic rays, discovered the positron, or antielectron, the first known antiparticle. Any antimatter in our part of the universe is necessarily very short-lived because of the overwhelming preponderance of ordinary matter, by which the antimatter is quickly annihilated.

Antimony [Sb] A dark grey powder usually about 240 mesh, melting point 630ÝC. Also known as Antimony Regulus, found in nature as stibnite. Used in white fire compositions, but mainly used in mixes containing gunpowder and aluminium to produce the "glitter effect". Antimony reacts less violently with oxygen than either aluminium or magnesium.

Antimony Disulphide [Sb2S3] Dark grey, sparkly powder. Fuel used in glitter compositions and commonly in white comets and stars. Fuel is sometimes used to increase sensitivity of flash powder. See Antimony Sulphide.

Antimony Fulminate One of a group of unstable, explosive compounds related to Mercury Fulminate.

Antimony Potassium Tartrate Also known under the name of Tartar Emetic. These poisonous, transparent crystals or white powder, are used to make Antimony Fulminate. Any moisture present can be driven off by heating to 100ÝC but above this and the chemical will decompose.

Antimony Sulphide [Sb2S3] This has usefulness in sharpening the report of firecrackers, salutes, etc. or to add colour to a fire.

Antimony Trisulphide Dirty black powder usually about 200mesh (there is also a red precipited form).Also known native ore, Stibnite. Similar in use to the metal powder although ignites easier. Synthetically produced material is crap.

Apparent Density The ratio of mass to volume of a finely powdered material, under stated conditions, which is always less than true density. Sometimes called loading density. Because apparent density depends on the method used to obtain it, the method should always be specified. Bulk Density.

Approved or approval Means sanctioned, endorsed, accredited, certified, or accepted as satisfactory by a duly constituted and nationally recognized authority or agency.

Aqua Fortis Old fashioned term for concentrated Nitric acid.

Aqua Regia A strong acid containing 1 part concentrated Nitric Acid and 3 parts concentrated Hydrochloric Acid. Store in a well closed glass bottle in a dark place. This acid will attack all metals, including gold and platinum. It is used in making some explosives.

Aqueous In fireworks, aqueous usually refers to solutions used for damping stars in manufacture.

Aquifer a subsurface geological structure that contains water.

Arachis Oil Peanut oil.

Archimedes 'Principle of Archimedes' states that a force equal to the weight of the displaced fluid buoys up a body immersed in a fluid. The principle applies to both floating and submerged bodies, and to all fluids. It explains not only the buoyancy of ships but also the rise of a helium-filled balloon and the apparent loss of weight of objects underwater.

Argon [Ar] gaseous element, discovered in 1894 by Sir William Ramsay and Lord Rayleigh. An odourless, tasteless, and colourless inert gas, it makes up 0.93% of the atmosphere by volume. Argon is used in light bulbs and neon signs, in refining reactive

elements, and for protection in arc welding.

Argillaceous Rocks Sediments of silts or clay. Common minerals are kaolinite and montmorillonite.

Arming as applied to fuses, the changes from a safe condition to a state of readiness for initiation. Generally a fuse is caused to arm by acceleration, rotation, clock mechanism or air travel, or by combinations of these.

Aromatic Compound is any of a large class of organic compounds including Benzene and compounds that resemble benzene in chemical properties. Aromatic compounds contain unusually stable ring structures, often made up of six carbon atoms arranged hexagonally. Some of the compounds, however, have rings with more or fewer atoms, not necessarily all carbon. Furan, for example, has a ring with four atoms of carbon and one of oxygen. Also, two or more rings can be fused, as in naphthalene. The characteristic properties of the class, notably the stability of the compounds, derive from the fact that aromatic rings permit the sharing of some electrons by all the atoms of the ring, which increases the strength of the bonds.

Arsenic Disulphide [As2S2] A red/orange fine powder, also known as realgar. Has been used in making white fires and smokes very limited use in modern day compositions.

Arsenic Sulphide, Yellow [As2S3] This Chemical is just as poisonous as its red brother and is also used in fireworks, somewhat. The common name is Kings Gold.

Arsenic Trisulphide Two forms a red and yellow powder, also known as Orpiment. The yellow form turns red at 170C. Used in easily ignited white stars and some smoke compositions. Used with Lampblack to produce the wonderful golden spur like effect of the traditional Flower Pot.

Arsenious Oxide [As4O6] A white, highly poisonous powder used in fireworks. It is also known as Arsenic Trioxide, Arsenious Oxide and Arsenous Acid. Its uses are similar to Paris Green.

Artillery is a term now applied to heavy firearms, as distinguished from Small Arms. Modern artillery includes a variety of long-range guns that fire their shells with rapid muzzle-velocity in a low arc; howitzers, which fire on a high trajectory at relatively nearby targets; antiaircraft guns, which fire rapidly and at high angles; armour-piercing anti-tank guns; and many field-artillery pieces used in support of infantry and other ground operations.

Asphalt A blackish brown lumpy powder, also known as Gilsonite and Asphaltum. Difficult to keep in powder form and has very limited uses. Very dirty to work with, also very sticky.

Asphaltum Also known as gilsonite and asphalt. Sometimes used as a substitute for carbon as a fuel. A black bituminous substance, best described as powdered tar.

Astronomical Unit (AU) means distance between the earth and the sun. One AU is @92,960,000 miles or 149,604,970 km.

Atmosphere The envelope of air surrounding the earth; also, the body of gases surrounding or comprising any planet or other celestial body. Atmospheric pressure may be measured as weight per area. On earth, normal air pressure at sea level is 14.7 pounds of weight per square inch, or 1033 grams of weight per square centimetre.

Atom The atom is the smallest unit of a chemical Element having the properties of that element. An atom contains several kinds of particles. Its central core, the nucleus, consists of positively charged particles, called Protons, and uncharged particles, called Neutrons. Surrounding the nucleus and orbiting it are negatively charged particles, called Electrons. Each atom has an equal number of protons and electrons. The nucleus occupies only a tiny fraction of an atom's volume but contains almost all of its mass. Electrons in the outermost orbits determine the atom's chemical and electrical properties. The number of protons in an atom's nucleus is called the Atomic Number. All atoms of an element have the same atomic number and differ in atomic number from atoms of other elements. The total number of protons and neutrons combined is the atom's Mass Number. Atoms containing the same number of protons but different numbers of neutrons are different forms, or Isotopes, of the same element.

Atomic absorption quantitative chemical method used for the analysis of elemental constituents.

Atomic Bomb A weapon deriving its great explosive force from the sudden release of Nuclear Energy through the fission, or splitting, of heavy atomic nuclei. Practical fissionable nuclei for atomic bombs are the isotopes Uranium-235 andPlutonium-239, which are capable of undergoing chain reaction. If the mass of the fissionable material exceeds the critical mass, the chain reaction multiplies rapidly into an uncontrollable release of energy. An atomic bomb is detonated, by bringing together, very rapidly (e.g., by means of a chemical explosion) two sub critical masses of fissionable material. The ensuing explosion produces great amounts of heat, a shock wave, and intense neutron and gamma radiation. The region of the explosion becomes radioactively contaminated, and wind-borne radioactive products may be deposited elsewhere as fallout.

Atomic mass - unit (amu) a unit of mass equal to 1/12 the mass of the carbon isotope with mass number 12, approximately 1.6604 x 10E-24 gram.

Atomic Number Often represented by the symbol Z, the number of Protons in the nucleus of an Atom. Atoms with the same atomic number make up a chemical Element. The elements are arranged in the Periodic Table in the order of their atomic numbers. Atomic Weight Mean (weighted average) of the masses of all the naturally occurring Isotopes of a chemical Element; the atomic mass is the mass of any individual isotope. Atomic weight is usually expressed in atomic mass units (amu); the atomic mass unit is defined as exactly 1/12 the mass of a carbon-12 atom. Each proton or neutron weighs about 1 amu, and thus the atomic mass is always very close to the Mass Number (total number of protons and neutrons in the nucleus). Because most naturally occurring elements have one principal isotope and only insignificant amounts of other isotopes, most atomic weights are also very nearly whole numbers. For the atomic weight of individual elements, see Element.

Atomic weight the average weight of an atom of an element, usually expressed relative to one atom of the carbon isotope taken to have a standard weight of 12.

Atomised In pyrotechnics, an atomised metal powder consists of regular spherical particles that may be as small as 5 microns in diameter.

Attitude The position or orientation of an aircraft, spacecraft, munitions, device, etc., either in motion or at rest, as determined by the relationship between its axes and some reference line or plane such as the horizon.

Auramine A certified Biological st

B

Back-Blast Rearward blast of gases from the breech of recoil-less weapons and rockets upon the burning of the propellant charge. It is sometimes referred to as breech-blast.

Bacteria any of numerous unicellular micro organisms of the class Schizomycetes, occurring in a wide variety of forms, existing either as free-living organisms or parasites, and having a wide range of biochemical, often pathogenic properties. Some bacteria are capable of causing human, animal or plant diseases; others are essential in pollution control because they breakdown organic matter in air and water.

Bag mine *Material to be added later*

Bakelite a synthetic thermosetting phenol-formaldehyde resin with an unusually wide variety of industrial applications ranging from billiard balls to electrical insulation.

Ballistic Cap for projectile, designed to improve its ballistic efficiency.

Ballistic Conditions which affect the motion of a projectile in the bore and through the atmosphere, including muzzle velocity, weight of projectile, size and shape of projectile, rotation of the earth, density of the air, elasticity of the air and the wind.

Ballistic Curve Actual path or trajectory of a bullet or shell.

Ballistic Efficiency Ability of a projectile to overcome the resistance of the air. Ballistic efficiency depends chiefly on the weight, diameter and shape of the projectile.

Ballistic Wave Audible disturbance or wave caused by the compression of air ahead of a projectile in flight.

Ballistics The science of the motion of projectiles.

Ballistite Smokeless powder used as a propelling charge in small arms and mortar ammunition.

Banger Usually a complete firework, designed to produce a loud ban, rather than a component of a larger firework (e.g. a mine) - which are better referred to as crackers.

Bar Derived from the Greek word "heavy". A bar is a measure of pressure; one bar is equal to 0.9869 atmospheres or 105 pascals.

Bare match Black match, or Quickmatch without a sleeve.

Barium [Ba] A metallic element, isolated by electrolysis in 1808 by Sir Humphrey Davy. It is a soft, silver-white Alkaline-Earth Metal. Its principal ore is barite. Various barium compounds are used as paint pigments, rat poison, a drying agent, and a water softener, and in pyrotechnics.

Barium Carbonate [BaCO3] A white precipitated powder (rhombic crystals), also known as Witherite. Used as acid neutraliser in compositions and too reduce the burning rate of some compositions. Sometimes used as delay agent in glitter compositions. Decomposes at a fairly high temperature, 1300 degrees.

Barium Chlorate [Ba(ClO3)2.H2O] A fine white crystalline powder (monoclinic crystals). Used to produce deep green colours. Due to its very sensitive nature extra care should be taken with this material, its use with other less sensitive substances will tend

to help reduce the sensitivity. Melting point is 414 degrees.

Barium Chloride (Barium chloride dihydrate). **[BaCl2.2H2O]** White granular powder. Also makes a relatively safe colouring agent for campfires, pine cones, and fireplace logs.

Barium Chromate [BaCrO4] Yellow powder. Oxidizer used in delay compositions, primarily in rockets.

Barium Nitrate [Ba(NO3)2] A fine white dense crystalline powder (cubic crystals), tends to go hard and lumpy. Although green colours are weak, it is often used in compositions with Barium Chlorate. Also used in the production of portfire and lance compositions. It is also present in some flash formulations, especially in reports/salutes. Its use with aluminium powder produces very bright effects at high temperature (waterfalls and illuminations lights, etc.) or silvery gold effects at lower temperatures. It melts at 500 degrees.

Barium Oxalate [BaC2O4.H2O] A white precipitated powder. Limited use.

Barium Peroxide [BaO2] A white powder. Very limited use in pyrotechnic compositions due to its highly reactive nature, decomposes in moisture therefore liable to heat up compositions containing aluminium.

Barium Sulphate [BaSO4] fine white powder. Used as a green colour agent, a high temperature oxidizer in strobe mixtures, sometimes as a delay agent and in glitter formulations.

Barrage 1) Mil. A barrier of fire from guns, etc. 2) Fwk. A combination of several fireworks, most usually Roman candles and/or mines, designed to be fired with a single ignition

Barricaded An intervening approved barrier, natural or artificial, of such type, size and construction as to limit the effect of an explosion on nearby buildings or exposures.

Base any substance which contains hydroxyl (OH) groups and furnishes hydroxide ions in solution; a molecular or ionic substance capable of combining with a proton to form a new substance; a substance that provides a pair of electrons for a covalent bond with an acid; a solution with a pH of greater than 7.

Base Plug Seal in base of firework or mortar tube.

Battery Actuation Cartridge May be electric, percussion or pneumatic: A controlled pressure cartridge used to force electrolyte into a dry-charge battery.

Battery In fireworks a combination of, say Roman candles, fused together for increased effect and/or duration. Similar to a firework barrage.

Bell Wire An expendable wire, also known as Bus wire, used in parallel or series in parallel circuits, to which are connected the leg wires of electric fuzes.

Bengal A pyrotechnic coloured flare.

Benzene [C6H6] colourless, flammable toxic liquid with a pleasant aromatic odour. Hydrocarbon, benzene is the parent substance of the Aromatic Compounds. It consists of an unusually stable hexagonal ring of six carbon atoms, each of which is attached to a hydrogen atom. Derivative compounds include toluene, phenol, and aniline. Obtained from coal tar and petroleum, benzene and its derivatives are used in making dyes, and plastics.

Benzoic Acid [C6H5COOH] White powder used to make metallic benzoates.

Beryllium a metallic element, first isolated in 1828 independently by Friedrich Wohler and Antoine Bussy. The silver-grey, Alkaline-Earth Metal is light, strong, high melting, and resistant to corrosion. It is used as a window material for X-ray tubes and as a shield and a moderator in nuclear reactors.

Bickford fuse A slow burning fuse used either for preparation of internal shell delays, or for timing sequential firings.

Binary Explosive A two component explosive based on safe-to-handle compounds such as hydrazine or nitro methane, shipped separately and united at the site to form a high-energy explosive.

Binder Compositions that hold together a charge of finely divided particles and increase the mechanical strength of plugs or pellets of these particles when consolidated under pressure. Binders usually are resins, plastics, asphaltics or hard waxes used dry or in solution.

Biodegradability the susceptibility of a substance to decomposition by micro-organisms; specifically, the rate at which compounds may be chemically broken down by bacteria and/or natural environmental factors.

Bismuth Fulminate One of a group of unstable, explosive compounds derived from Fulminic Acid.

Bismuth Trioxide [Bi2O3] Light yellow powder used as a safe alternative to lead tetraoxide in crackling microstars (dragon eggs).

Black match Usually a cotton thread coated with blackpowder, in its raw state, also known as Quickmatch. Black match contained within a paper tube is usually referred to as piped match.

Black Powder A deflagrating or low explosive compound, consisting of a mixture of an alkali nitrate, usually potassium or sodium nitrate, mixed with charcoal and sulphur, which is mostly pressed, granulated and classified into definite grain fractions. It is easily ignited, friction sensitive, and produces dense smoke. Still used as a propellant in fireworks although the advent of so-called smokeless powder has now reduced its role in commerical military type rockets; few remaining military uses, such as igniters, in fuses to give short delay, in blank ammunition and as spotting charges. It deflagrates faster than it detonates; and is thus classified as a low explosive. The standard composition is: 75% potassium nitrate, 10% sulphur and 15% charcoal. There are also graded compositions containing 74, 70, 68 or 64% potassium nitrate. Corresponding compositions based on sodium nitrate are known as B-Black Powder.

Blackpowder A composition, comprising Potassium Nitrate, Sulphur and Charcoal in the ration 75:15:10 widely used in fireworks manufacture as a propellant and as the basis for compositions containing metal powders. It is considered by most people that blackpowder does not detonate on ignition, but merely burns extremely fast! Common name for Gunpowder.

Blank Ammunition containing no projectile but which does contain a charge of low explosive, such as black powder, to produce a noise; used in training, in signalling and in firing salutes.

Blast area The area of a blast, including the area immediately adjacent, within the influence of flying rock missiles.

Blast Cube Angle iron frame covered with aluminium sheets; used for testing effectiveness of blast.

Blast Shield This is a specialty type of portable protective shield used by both bomb technicians and tactical personnel that is designed to protect the user from fragments, thermal effects and overpressure.

Blast Sudden air pressure created by the discharge of a gun or the explosion of a charge.

Blast Tube Device used for the study of shock waves and for calibration of air-blast gauges. *See Shock Tube.*

Blaster The person or persons authorized to use explosives for blasting purposes

Blasting Agent Any material or mixture consisting of a fuel (combustible) and oxidizer, intended for blasting, not otherwise classified as an explosive provided that the finished product, as mixed and packaged for shipment, cannot be detonated by a commercial grade No. 8 blasting cap.

Blasting Cap (American name for a Detonator) A small thin-walled cylindrical case containing a sensitive explosive. Blasting caps serve as initiators of explosive charges. They consist of a cylindrical copper or aluminium capsule containing a primary charge of an initiating explosive or a mixture of initiating explosives (e.g. lead azide with lead trinitroresorcinate); in order to achieve a higher brisance, they also contain a secondary charge of a high brisance explosive (e.g. Tetryl; PETN; Cyclonite). A blasting cap can be ignited by the flame of a safety fuse or electrically, or no electrically (as in the case of Shock Tube. In the past, 10 standard types of blasting caps were marketed; these differed from each other by the quantity of the explosive in the charge and by their size. Currently, No. 8 blasting cap (0.3 g primary charge. 0.8 g secondary charge, 4-50mm in length and 7.0 mm in external diameter) is, for all practical purposes, the main type of blasting cap on the market.

Blasting Galvanometer An electrical resistance instrument designed specifically for testing electric detonators and circuits containing them. Along with blasting ohmmeters and blaster's multimeters, it is used to measure resistance or to check electrical continuity.

Blasting Gelatin (*nitroglycerine with about 8% nitrocellulose added*) will explode at a temperature of over 4700Ý C produces about 680 kilocalories (2700 B.T.U.) of heat, over 9 cubic feet of gas is formed, with a pressure of about 13,000 atm (190,000 lb./in.) which develops if the explosion takes place in an enclosed space. Although the amounts of heat and gas liberated in the explosion are not very much more than twice those produced in the explosion of an equal amount of gunpowder, which is a much slower explosive, the shattering power of blasting gelatin (*and similar explosives*) is very much greater than that of gunpowder, this being due mainly to the greater speed of the explosion reaction.

Blasting Log Law/regulations which may require a written record of information about a specific blast.

Blasting powder Blasting powder may be made with either Potassium Nitrate (type A) or Sodium Nitrate (type B) as the oxidant.

Blind shell A shell that fails to burst, having been successfully launched from its mortar. Potentially very dangerous. Sometimes referred to as a Black Shell

Blinker An effect of periodic burning giving the effect of a flashing composition or strobe.

Blowback Escape, to the rear and under pressure, of gases formed during the firing of a gun.

Boiling Point The temperature at which a substance boils, or changes from a liquid to a vapour or gas, through the formation and rise to the surface of bubbles of vapour within the liquid. In a stricter sense, the boiling point of a liquid is the temperature at which its vapour pressure is equal to the local atmospheric pressure. Decreasing (or increasing) the pressure of the surrounding gases thus lowers (or raises) the boiling point of a liquid. The quantity of heat necessary to change 1 g of any substance from liquid to gas at its boiling point is known as its latent heat of vaporization.

Bomb an explosive device/substance that is placed, dropped, thrown or projected with the unlawful intention of causing injury, death, or destruction of property, or creating a disturbance.

Bombette In essence a mini shell, usually found as a component of a Roman candle, and less often as a component of a mine or even as a sub component of a shell.

Boom Powder A pyrotechnic ignition mixture designed to produce many incandescent particles. A typical boom composition is:

*Ingredient**Parts By Weight*Iron Oxide 50Titanium (Powdered) 32.5Zirconium (Powdered) 17.5including about 1 part cellulose nitrate as a binder **Booster Charge** The final high explosive component of an explosive train that amplifies the detonation from the lead or detonator so as to reliably detonate the main high explosive charge. Also used loosely to indicate a reinforcing or augmenting charge.

Borax [Na2B4O7.10H2O] is sodium tetraborate decahydrate, the chemical compound occurs as a colourless, crystalline salt or a white powder. Borax is used as an antiseptic, cleansing agent, water softener, corrosion inhibitor in antifreeze, and flux for silver soldering, and in the manufacture of fertilizers, Pyrex glass, and pharmaceuticals.

Bore The cylindrical, and usually rifled, portion of the gun tube, or barrel interior, extending from the forcing cone to the muzzle. Bore is used both for the inside surface of the barrel or tube of a gun, with its rifling, and for the cylindrical space enclosed by that portion of the tube.

Boric Acid [H3BO3] Off-white crystalline powder. Used as a buffer in aluminium compositions such as the production of stars, to prevent the alteration of the pH in the dampened mixture (aluminium's alkaline decomposition can create Heat). Used in sparkler production.

Bottom fused The normal method of fusing of a shell, where the shell delay is ignited by the lifting charge of the shell. Also, for cakes where fusing is at the base of each tube.

Bottom shot Typically a maroon as the last shot of a multibreak shell

Bounce A charge of blackpowder at the base of a gerb - used to give an audible "crack" at the end of the burning of the gerb, and to enhance the effect.

Boxed finale A rapid firing array, usually of shells, with a single point of ignition. Physically they comprise a number of pre-loaded mortars, very often with titanium salute shells.

BPA British Pyrotechnics Association - a trade association concerned with all aspects of fireworks safety and use in the UK. Divided into Retail and Display sections.

Brass This is an alloy of Copper and Zinc. Some also contain a small percentage of Tin. The commercial grade is suitable in powdered form. It is used in some fireworks formulas.

Breaching Charges Used to destroy concrete-slab bridges, bridge beams, bridge piers, bridge abutments, and permanent field fortifications. The size, shape, placement, and tamping or confinements of breaching charges are critical to success.

Break A normal shells is referred to as "single break". In a multibreak shell there are many sequential bursts, each a separate entity (cf shell of shells for instance).

Bridge wire A relatively fine resistance wire incorporated into an ignition element connecting the ends of the leg wires inside an electric detonator and which is imbedded in the ignition charge of the detonator.

Brisance The performance of an explosive cannot be expressed by means of a single characteristic parameter. Brisance is the destructive fragmentation effect of a charge on its immediate vicinity. The relevant parameters are the detonation rate and the loading density (compactness) of the explosive, as well as the gas yield and the heat of explosion. The higher the loading density of the explosive (moulding or pressing density), the higher its performance concentration per unit volume; also, the faster the reaction rate, the stronger the impact effect of the detonation. Moreover, an increase in density is accompanied by an increase in the detonation rate of the explosive, while the shock wave pressure in the detonation front varies with the square of the detonation rate. Thus it is very important to have the loading density as high as possible. This is particularly true for Shaped Charges. Kast introduced the concept of "brisance value", which is the product of loading density, specific energy and detonation rate. Brisance tests are upsetting tests according to Kast and HeB; the compression of a copper cylinder is determined by actuating a piston instrument; alternatively, a free-standing lead cylinder is compressed by the application of a definite cylindrical load of the explosive being tested.

Brisant Sudden, sharp, violent. A descriptive term which, when applied to explosions, indicates a powerful impulse of short duration.

British Standard Prepared in the late 1980’s for consumer fireworks. The standard sets performance, labelling and constructional requirements for a variety of consumer fireworks available to the public in the UK and also prescribes test regimes and methods for compliance.

British Thermal Unit (btu) the quantity of heat necessary to raise the temperature of 1 pound of water by 1 oF.

Brocade Long burning star similar to but brighter and shorter burning than a kamuro star

Buffer a solution selected or prepared to minimize changes in hydrogen ion concentration, which would otherwise occur as a result of a chemical reaction. A solution that can keep its pH, (i.e., its relative acidity or alkalinity) constant despite the addition of strong acids or bases. Buffer solutions contain either a weak acid or weak base and

one of their salts. *See pH.*

Bulk Density The mass per unit volume of bulk materials. Used in connection with packaging, storage or transportation.

Bullet-Resistant Magazine walls or doors of construction resistant to penetration of a bullet of 150-grain M2 ball ammunition having a nominal muzzle velocity of 2,700 ft/sec fired from a .30-caliber rifle from a distance of 100 ft perpendicular to the wall or door. When a magazine ceiling or roof is required to be bullet-resistant, the ceiling or roof shall be constructed of materials comparable to the sidewalls or other materials that will withstand penetration of the bullet described above when fired at an angle of 45 degrees from the perpendicular. Tests to determine bullet resistance should be conducted on test panels or empty magazines that will resist penetration of 5 out of 5 shots placed independently of each other in an area at least 3 ft. x 3 ft.

Burning (of propellant) Linear Burning Rate.

Burning Typically an exothermic oxidation/reduction reaction. For fireworks the oxidant is usually a solid oxygen-rich ionic salt such as Potassium Nitrate.

Burst Explosion of a projectile in the air, or when it strikes the ground or target.

Burster Explosive charge used to break open and spread the contents of projectiles, bombs or mines.

Bursting Charge Quantity of an explosive that breaks the casing of a projectile to produce demolition, fragmentation or chemical action.The internal charge in a shell designed to break the shell at the predetermined time, spreading and igniting the contents of the shell. Bursting charges are typically made of blackpowder (for effects shells) or flash powder (for colour shells).

Butterfly burst A bust of a cylindrical tube from a central point, thus producing an effect akin to the wings of a butterfly. The term is also used for the more complicated burst pattern of a "butterfly" shell, although in many ways the theory of action is similar.

C

C4 High explosive composition C4, often referred to in Hollywood action films as plastic explosive.

Cab-O-Sil™ (fumed silica, colloidal silica). **[SiO2]** Fluffy white powder. Used as an anti-caking agent to retard water absorption by hygroscopic chemicals and to make chemicals flow more freely. Sometimes used in flash powders. Four ounces in weight, approximately one-half gallon volume.

Caesium [Cs] metallic element, discovered by spectroscopy in 1860 by Robert Bunsen and Gustav Kirchhoff. Ductile, soft as wax, and silver-white, it is the most alkaline element Alkali Metals) and the most reactive metal. Caesium metal is used in photoelectric cells and various optical instruments; caesium compounds, in glass and ceramic production. The cesium-137 radioactive isotope is used to treat cancer.

Cake firework term for a multishot battery, various roman candles fused together (e.g. 37 shot cakes).

Calcium [Ca] metallic element, first isolated in 1808 by Sir Humphrey Davy. It is a silver-white, soft, malleable Alkaline-Earth Metal. The fifth most abundant element (3.64%) of the earth's crust, it is not found uncombined but occurs in numerous compounds, e.g., Apatite, Calcite, Dolomite, Iceland Spar, Limestone, and Marble. Calcium acts as a reducing agent in the preparation of other metals. It occurs in most plant and animal matter, and is essential for the formation and maintenance of strong bones and teeth. Calcium helps to regulate the heartbeat and is necessary for blood clotting.

Calcium Carbide [CaC2] greyish crystalline powder normally packed in waterproof and airtight metal containers. Mixed with water it forms Acetylene Gas which is EXPLOSIVE. It is used in toy cannons.

Calcium Carbonate [CaCO3] This occurs as the mineral Calcite. It is used for Phosphorous Torpedoes, but does not have any dangerous properties in itself. Also as an acid absorber in fireworks. A white precipitated powder. Used occasionally as a neutralizer.Used as a colour agent in reddish orange stars, sometimes as a filler in pyro-adhesive.

Calcium Fluoride [CaF2] This finds its use in a smokeless firework mixture and is not used elsewhere. It is a white powder, also known as Fluorspar.

Calcium Oxalate [CaC2O4] A fine white precipitated powder. Sometimes used in "glitter effect" compositions and magnesium flares.

Calcium Phosphide [Ca3P2] This compound, which comes as grey lumps, must be kept dry. Upon contact with water it will form the flammable gas, Phosphine (highly toxic!). It is used in signal fires.

Calcium Silicide [CaSi2] A dark grey/black crystalline powder. Used in smoke compositions and in self heating compositions, used to heat cans on camping holidays, as the fuel

Calcium Sulphate [CaSO4] White powder. Used as a high temperature oxidizer and reddish-orange colour agent in strobe compositions.

Calculus A branch of mathematics that studies continuously changing quantities. It was developed in the 17th century independently by Sir Isaac Newton and G.W. Leibniz. The calculus is characterized by the use of infinite processes, involving passage to a Limit. The differential calculus arises from the study of the rate at which a function, usually symbolized by y or f (x), changes relative to a change in the independent variable, usually x. This relative rate can be computed from a new function-the derivative of y with respect to x, denoted by dy/dx, yÝ, or fÝ(x)-arrived at by a process called differentiation. Formulas have been developed for the derivatives of all commonly encountered functions. For example, if y = xn for any real number n except -1, then yÝ = nxn-1, and if y = sin x, then yÝ = cos x. In physical applications, the independent variable is frequently time, e.g., if s = f (t) expresses the relation between the distance s travelled and the time t elapsed, then sÝ = fÝ(t) represents the rate of change of distance with time, i.e., the speed or velocity Motion) at time t. Geometrically, the derivative is interpreted as the slope of the line tangent to a curve at a point. This view of the derivative yields applications, e.g., in the design of optical mirrors and lenses and the determination of projectile paths. The integral calculus arises from the study of the limit of a sum of elements when the number of such elements increases without bound while the size of the elements diminishes. Conventionally, the area A under the curve y = f(x) between the two values x = a and x = b is symbolized by A = baf(x)dx, called the definite integral of f(x) from a to b. The area is approximated by summing the products of f(x) and dx for each of the infinitely small distances (dx) that comprise the measurable distance between a and b. This method can be used to determine the lengths of curves, the areas bounded by curves, and the volumes of solids bounded by curved surfaces. The connection between the integral and the derivative is known as the Fundamental Theorem of the Calculus, which, in symbols, is baf(x)dx = F(b) - F(a), where F(x) is a function whose derivative is f(x). The calculus has been developed to treat functions not only of a single variable but also of several variables and is the foundation for the larger branch of mathematics known as Analysis.

Calibration the checking, adjusting, or systematic standardizing of the graduations of a quantitative measuring instrument.

Calibre -Fwk. In firework terms usually the inside diameter of the firing tube, although strictly the diameter of the projectile.

Calibre -MIL. 1) Diameter of the bore of a gun. In rifled gun bores, the calibre is obtained by measuring between opposite lands. A calibre .45 revolver has a barrel with a land diameter 45/100 of an inch. 2) Diameter of a projectile. 3) Unit of measure used to express the length of the bore of a weapon. The number of calibres is determined by dividing the length of the bore of the weapon, from the breech face of the tube to the muzzle, by the diameter of its bore. A gun tube whose bore is 40 feet (480 inches) long and 12 inches in diameter is said to be 40 calibres long.

Calorie A calorie (cal) is a unit of energy required to raise the temperature of 1 gram of water 1 oC at 1 atmosphere pressure; 1 cal = 4.1840 joules. Nutritionists use the kilocalorie (1,000 cal) to calculate the calorific beer content consumed after one of Big Bang’s firework displays.

Calorimeter A device for measuring heat of combustion (under compressed oxygen) or heat of explosion (under an inert gas such as argon); the latter is used for propellants, explosives and pyrochemical mixtures which react without outside oxygen, not to be mistaken for colorimeter, an apparatus to measure colour.

Campfire Blue (cuprous chloride, copper(I) chloride). **[CuCl]** Greenish-blue powder used as a blue colour agent. Also makes a relatively safe colouring agent for campfires, pine cones, and fireplace logs.

Camphor [C10H16O] A ketone found in the wood of the Camphor tree, native to Taiwan and a few of our states. For the best results, buy the granulated, technical grade. Used in explosives and fireworks.

Candle Abbreviated term for Roman candle

Canister Metal cylinder

Cannelure 1) A ring-like groove in the jacket of a bullet that provides a means of securely crimping the cartridge case to the bullet; analogous to the crimping groove in artillery ammunition. 2) Ring-like groove for locking the jacket of an armour-piercing bullet to the core. 3) Ring-like groove in the rotating band of a projectile, intended to lessen the resistance offered to the gun riflings. 4) Groove around the base of the cartridge case, where the extractor takes hold.

Cannonade *Material to be added later*

Cap Amorce, for use in toy pistols

Cap Sensitivity The sensitivity of an explosive to initiation by a detonator. An explosive material is considered to be cap sensitive if it detonates with an IME No. 8 Test Detonator.

Capacitance In electricity, the capability of a body, a system, or an Electric Circuit for storing electric charge. Capacitance, in units of farads, is expressed as the ratio of stored charge in coulombs to the applied potential difference in volts. In electric circuits, devices designed to store charge are called Capacitors. When alternating current flows through a capacitor, the capacitor produces a reactance, inversely proportional to the capacitance, that resists the current flow (Impedance).

Capacitor or condenser, a device for storing electric charge. Simple capacitors usually consist of two plates made of an electrically conducting material (e.g., a metal) separated by a nonconducting material (e.g., glass, paraffin, mica, oil, or air). If an electric Potential (voltage) is applied to the capacitor plates, the plates will become charged, one positively and one negatively. If the externally applied voltage is then removed, the capacitor plates remain charged, and the electric charge induces an electric potential between the two plates. This phenomenon is called electrostatic Induction. The capacity of the device for storing electric charge (i.e., its capacitance) can be increased by increasing the area of the plates, by decreasing their separation, or by varying the substance used as an insulator. The Dielectric constant is a measure of the increase in capacitance due to a particular insulator used to separate the plates. The Leyden jar, a form of capacitor invented at the University of Leiden in the 18th century, consists of a narrow-necked glass jar coated on part of its inner and outer surfaces with conductive metal foil.

Capillarity or capillary action, phenomenon in which the surface of a liquid is elevated or depressed when it comes in contact with a solid. The result depends on the outcome of two opposing forces, Adhesion and Cohesion. Adhesion between glass and water causes the water to rise along a glass wall until this force is balanced by the cohesive force acting to minimize the liquid's surface area (Surface Tension). When adhesion is less than cohesion, as with glass and mercury, the surface is lowered. The upward flow of water in soil and in plants is partially caused by capillarity.

Capped Fuse Safety fuse to which a plain detonator has been crimped.

Capping Usually a rolled kraft paper tube used to connect several fuses together in a spark-proof join.

Carbon Black *See Lampblack*.

Carbon Dioxide [CO2] chemical compound, occurring as a colourless, odourless, tasteless gas that is about 1 + times as dense as air under ordinary conditions. It does not burn and will not support combustion of ordinary materials. Its weakly acidic aqueous solution is called Carbonic Acid. The gas, easily liquefied by compression and cooling, provides the sparkle in carbonated beverages. Solid carbon dioxide, or dry ice, is a refrigerant. Dough rises because of carbon dioxide formed by the action of yeast and baking powder. Carbon dioxide is a raw material for photosynthesis in green plants, and is a product of animal respiration and of the decay of organic matter. Carbon dioxide occurs both free and combined in nature, and makes up about 1% of the volume of dry air. It can cause death by suffocation if inhaled in large amounts.

Carbon [C] is a non-metallic element, known since ancient times. Pure carbon forms are amorphous carbon (found in such sources as Charcoal, Coal, Coke, Lignite, and Peat) and the crystals Graphite, a very soft, dark-grey or black, lustrous material, and Diamond, the hardest substance known. All living organisms contain carbon. Carbon has seven isotopes; carbon-12 is the basis for Atomic Weights; carbon-14, with a half-life of 5,730 years, is used to trace chemical reactions and to date geologic and archaeological specimens

Carbon Monoxide [CO] colourless, odourless, tasteless, extremely poisonous gas that is less dense than air under ordinary conditions. It burns in air with a characteristic blue flame, producing carbon dioxide. It is a component of the artificial fuels producer gas and water gas. As a reducing agent, it removes oxygen from many compounds and is used in the reduction of metals from ores. When air containing as little as 0.1% carbon monoxide by volume is inhaled, the oxygen of haemoglobin is replaced by the carbon monoxide, resulting in fatal oxygen starvation throughout the body.

Cartridge 1) A preformed unit of high explosive wrapped to a predetermined diameter and length; a plug; stick of dynamite; a soft plastic stick of AN/FO or slurry. 2) Round of ammunition wherein the propellant and primer are contained in a casing and in which the propellant, primer and projectile are assembled, stored, shipped and issued as a complete unit.

Cartridge Bag Cloth bag holding the propelling charge for some types of cannon.

Cartridge Base Container that holds the primer and propellant and to which the projectile may be affixed.

Cartridge Density the ratio between the weight of an explosive cartridge and its volume.

Case Typically the tube containing the pyrotechnic composition of the firework.

Cast Loading HE shell by the pouring of molten high-explosive filler into the shell body.

Castor Oil is used in some powders to reduce the sensitiveness and to waterproof the mixture. Yellow coloured oil. Used as a protective coating for Magnesium in flare compositions. But also acts as a binder and lubricant in the hydraulic pressing of compositions.

Catalyst A substance which, in small amounts, influences a chemical reaction without

chemically changing it. A substance that causes a change in the rate of a chemical reaction without itself being consumed by the reaction. Catalysts, which work by changing a reaction's activation energy, or minimum energy needed for the reaction to occur, are used in numerous industrial processes. Substances that increase the reaction rate are called positive catalysts, or simply catalysts, whereas substances that decrease the reaction rate are called negative catalysts, or inhibitors. The presence of a small amount of an acid or base may catalyse some reactions. Finely divided metals (e.g., platinum, copper, iron, palladium, rhodium) or metal oxides (e.g., silicon dioxide, vanadium oxide) may also serve as catalysts. Biological catalysts are called Enzymes.

Category 1 firework Indoor firework as defined by British standard 7114; part 2

Category 2 firework Garden firework as defined by British standard 7114; part 2

Category 3 firework Display firework as defined by British standard 7114; part 2

Category 4 firework Fireworks defined in the British Standard as being not suitable for sale to the general public. Generally larger professionally fired display fireworks.

Catherine Wheel The traditional name for a spinning firework. The name derives from St. Catherine.

Cathode The negative pole of a direct current device. Opposite to Anode.
Concentration measure of the relative proportions of two or more quantities in a mixture compound). Concentrations may be expressed in a number of ways. The simplest is in terms of a component's percentage by weight or volume. Mixtures of solids or liquids are frequently specified by weight-percentage concentrations, whereas mixtures of gases are usually specified by volume percentages. Very low concentrations, such as those of various substances in the atmosphere, are expressed in parts per million (ppm). The molarity of a solution is the number of moles of solute per litre of solution. The molality of a solution is the number of moles of solute per 1,000 grams of solvent. The mole fraction of a solution is the ratio of moles of solute to the total number of moles in the solution.

Condensate water obtained by evaporation or a product that has changed from a gaseous or vaporous form to a liquid form.

Conductance a measure of the conducting power of a solution equal to the reciprocal of the resistance. The resistance is expressed in ohms.

Conduction is the transfer of Heat or Electricity through a substance, resulting from a difference in temperature between different parts of the substance or from a difference in electric Potential. Heat may be conducted when the motions of energetic (hotter) molecules are passed on to nearby, less energetic (cooler) molecules, but a more effective method is the migration of energetic free electrons. Conduction of electricity consists of the flow of charges. Metals are thus good conductors of both heat and electricity because they have a high free-electron density.

Conductivity the ability of a material to carry current or heat.

Cone A specialised type of fountain in the shape of a cone. The advantages of a cone are predominantly ease of filling, and the fact that the burning area increases as the fireworks proceeds, thus compensating for the increase in diameter of the choke.

Confinement may be defined as an inert material of some strength and having a given wall thickness, situated in the immediate vicinity of an explosive. Priming or heating the explosive materials produces different results, according to whether they are located in a stronger or a weaker confinement. If confined by thick steel, almost any explosive will explode or detonate on being heated; on the other hand, they burn on contact with an open flame if unconfined Combustion; Mass Explosion Risk), except Initiating Explosives. The destructive (fragmentation) effect of an explosion becomes stronger if the explosive is confined (stemmed) in an enclosure such as a borehole. In the absence of natural confinement, the explosive charge is often embedded in an inert material such as clay. The process by which some explosives, e.g blackpowder, can change from extremely rapid burning to something approaching detonation. For instance, blackpowder confined in a tube will produce a loud report when lit, whilst blackpowder burning loose does not.

Connecting Wire An insulated expendable wire used between electric blasting caps and the leading wires or between the bus wire and the leading wires, used to extend the firing line or legwires in an electric blasting circuit.

Contamination a general term signifying the introduction of chemicals or waste which renders the product unfit for its intended use.

Continuity An electric circuit is said to be continuous when it is complete - thus a continuity check of a circuit is carried out to ensure that the circuit is not open.

Convolute wound tube A tube wound from a piece of paper the same width as the tube is long. Convolute tubes tend to be stronger than spiral wound tubes, although they are also more expensive to produce.

Cook-Off The detonation or deflagration of an explosive-filled device caused by externally applied heat.

Cooling salt Either sodium chloride or sodium carbonate incorporated in a high explosive to reduce the heat of the explosion as in permitted (permissible) explosives. A flame-depressant, isothermic chemical.

Copal Gum *See Gums*

Copper [Cu] If produced as a powder either flake or atomised is a coppery/brown colour, in fact, it is the only element to be found in nature having that colour. Can be used in the production of blue colours but can be expensive.

Copper Acetoarsenite [(CuO)3As2Cu(C2H3O2)2] A bright green/turquoise coloured fine powder, also known as Paris green, Imperial Green Kings Green or Vienna Green and Shweinfurtergrun. Still produces some of the best blue colours, although its use is now very limited, still used as an insecticide.

Copper Arsenate [CuHAsO3] A fine, light green, poisonous powder. It is used in the technical grade for fireworks.

Copper Carbonate [CuCO3.Cu(OH)2 or 2CuCO3.(OH)2]. A green coloured precipitated powder, also known as malachite or azurite. Used most commonly with ammonium perchlorate in the production of very good blue colours.

Copper Chlorate [Cu(ClO3)2.6H2O] technically this is Cupric Chlorate. A poison used in fireworks as an oxidizer and to add colour.

Copper Chloride [CuCl2] An oxidizer and colour imparter used in fireworks. Purchase the brownish-yellow technical grade. This is a poisonous compound.

Copper Nitrate [Cu(NO3)2.3H2O] technically this is Cupric Nitrate *(but would ruin the old joke about what is a policeman's pay? Depends if he's on copper nitrate)*. These blue crystals absorb water, as you can see from the formula. It is sometimes used in fireworks.

Copper Oxide [CuO] A fine black dusty powder, also available in red. Used in numerous traditional blue compositions. Generally requires some form of intensifier i.e. a chlorine donor to produce satisfactory blues.

Copper Oxychloride [3CuO.CuCl2.3H2O] A turquoise coloured powder. Cheap blue coloured compositions can be produced with this compound.

Copper Sulphate [CuSO4.5H2O] Known as Blue Vitriol, this poisonous compound is available as blue crystals or blue powder. It can be purchased in some drugstores. Used in fireworks for blue stars.

Copper Sulphide [CuS] As are the other copper salts, this is also used in fireworks to add colour. The technical grade is suitable and is black in colour. You can make your own by passing Hydrogen Sulphide into a Copper salt.

Copper(I) Chloride (*cuprous chloride*). **[CuCl]** Greenish-blue powder used as a blue colour agent. Also makes a relatively safe colouring agent for campfires, pine cones, and fireplace logs.

Copper(II) Carbonate (*cupric carbonate, basic*). **[CuCO3.Cu(OH)2]** Bluish-green powder used as a blue colour agent.

Copper(II) Chloride (*cupric chloride*) **[CuCl2]** Fine crystals used as a blue colour agent. Also makes a relatively safe colouring agent for campfires, pine cones, and fireplace logs.

Copper(II) Fluoride (*cupric fluoride*). **[CuF2]** Bluish powder used as a blue colour agent and halogen donor (flame colour enhancer).

Copper(II) Oxide, black (*cupric oxide*) **[CuO]** Black powder used as a blue colour agent.

Copper(II) Oxychloride [3CuO.CuCl2O3.5H2O] Bluish-green powder used as a blue colour agent.

Copper(II) Sulphate (*copper(II) sulphate, pentahydrate; cupric sulphate*)**. [CuSO4.5H2O]** Blue crystals used as a blue colour agent.

Cord, Detonating Tube containing a core of high explosive.

Cordite Double-base powder in the form of cords, composed of gun-cotton, nitro-glycerine and mineral jelly, used by some foreign nations as a propellant in rounds of ammunition. Designation for double base (nitroglycerin-nitrocellulose) gun propellants in the United Kingdom.

Cosmic Rays *(Not Rup Bagha's sunglasses)* The extremely high-energy subatomic particles that bombard the atmosphere from outer space. Cosmic-ray primaries seem to be mostly protons, hydrogen nuclei, but also comprise heavier nuclei. On colliding with

atmospheric particles, they produce many different kinds of lower-energy secondary cosmic radiation.

Cosmic Strings A hypothetical supermassive thread-like filament of matter

Countdown The time period in which a sequence of events is carried out to launch a rocket; the sequence of events.

Covalent bond A type of chemical bond in which electrons are shared by the participating atoms. This type of bond typically occurs between nonmetallic elements. In fireworks the important occurrence is in high energy species in the flame producing colours.

Cracker A small tube filled with flash powder, although sometimes contains a blackpowder based composition, fused with several other units into an assembly of many crackers often referred to as a "Chinese cracker". A novelty cracker, commonly used at Christmas in the UK is another use of the term.

Crackle A relatively recent effect comprising many small sharp bangs, thrown from a relatively low intensity comet. Chemically, most crackle compositions contain either lead or Bismuth oxides.

Crimp The folded ends of paper explosive cartridges; the circumferential depression at the open end of a fuse cap or igniter cord connector that serves to secure the fuse; or the circumferential depression in the blasting cap shell that secures a sealing plug or sleeve into electric or nonelectric detonators.

Crimping The act of securing a fuse cap or igniter cord connector to a section of a safety fuse by compressing the metal shell of the cap against the fuse by means of a cap crimper.

Critical Diameter The minimum diameter for propagation of a detonation wave at a stable velocity. Critical diameter is affected by conditions of confinement, temperature, and pressure on the explosive. It is strongly texture dependent, and is larger in cast than in pressed charges. Finely dispersed gas inclusions considerably reduce the critical diameter. In the case of very insensitive materials - ammonium nitrate for example, the critical diameter may be very large. While in explosive products such as DEXS the critical diameter may be a cross-section as small as 1/64".

Critical Humidity The humidity at which the material is in equilibrium with its environment with respect to moisture content.

Critical Mass Combustion, or burning, is a term usually employed to describe a reaction between a fuel and atmospheric air. This typically occurs when a small quantity of explosives burns.

Croaker *See Screecher*

Cross match Typically a piece of thin raw match used to facilitate ignition of a shell’s internal time fuse. Generally made by either splitting or punching the time fuse.

Crossette The another term for a splitting comet.

Crossing stars Typically a pyrotechnic effect formed by fitting two stars together in a tube with a central bursting charge. Also known as French Splits.

Crown chrysanthemum Typically a chrysanthemum like shell burst with long burning stars that continue to fall to the ground after the normal maximum burst diameter. Very often the stars have a colour change at the end of their flight.

Crown wheel *see Flying saucer*

Cryogenics Science concerned with the production and maintenance of very low temperatures, and with the effects that occur under such conditions. Although it is impossible to reach absolute zero, a temperature as low as about one millionth of a degree on the Kelvin scale above absolute zero can be attained. Low temperatures are achieved by removing energy from a substance. By using a succession of liquefied gases, a substance may be cooled to as low as 4.2ÝK, the boiling point of liquid helium. Still lower temperatures may be reached by successive magnetization and demagnetisation. Some unusual conditions, notably Superconductivity and Super fluidity, prevail at cryogenic temperatures.

Cryolite [Na3AlF6] Off white powder, also known as Greenland Spar. Used in the production of yellow coloured compositions. Synthetically produced material is poor. (sodium fluoaluminate).

Crystal, solid body bounded by natural plane faces that is the external expression of a regular internal arrangement of constituent atoms, molecules, or ions. The particles in a crystal occupy positions with definite geometrical relationships to each other, forming a kind of scaffolding called a crystalline lattice. On the basis of its chemistry and the arrangement of its atoms, a crystal falls into one of 32 classes; these in turn are grouped into seven systems according to the relationships of their axes. Differences in the physical properties of crystals sometimes determine the use to which they can be put in industry.

Cupric Oxide Limited use, used in starter compositions.

Curing The chemical process undergone by a thermosetting plastic by which the liquid resin cross-links to form a solid. This may be initiated, or accelerated, by heat. Curing generally takes place during the moulding operation, and may require from just a few seconds to several hours for its completion.

Current the flow or rate of flow of electric force in a conductor, from a point of higher potential to one of lowers potential. Measured in amperes.

Current Density The amount of electric current passing through a cross-sectional area of the conductor in a given unit of time; commonly expressed in amperes per square centimetre.

Current Leakage Portion of the firing current bypassing part of the blasting circuit through unintended paths.

Cut star usually prepared from a rolled sheet of damp star composition which is cut into squares.

Cut-off A break in a path of detonation or initiation caused by extraneous interference, such as flyrock, debris, or shifting ground.

Cutting Charges serve to cut through iron plates, cables, bridge trusses, etc. They are

constructed on the principle of Shaped charges, but are not rotationally symmetrical; their shape is that of long channels (grooves). The cutting depth of these charges depends to a considerable extent on the thickness and lining material of the angular or semi-circular groove; in addition, the optimum distance from the target must be determined in advance. As in rotationally symmetrical hollow charges, a jet of highly accelerated gases and metal fragments is produced.

Cyclonite *Material to be added later*

Cyclotol The name given to RDX / TNT mixtures with compositions varying between 50:50 and 75:25. RDX and Composition B.

Cylinder shell An aerial shell of typically European manufacture which is cylindrical in form. Very often a "stack" of cylinder shells is combined, with suitable modification, to produce a typical multibreak shell. Cylinder shells are usually "spiked" to produce a harder burst.

D

Dahlia shell A spherical shell burst, similar to a peony, but usually with fewer, but very bright stars (often containing magnesium).

Dark fire In firework terminology the low light-emitting composition applied to the burning surface of stars which can act as a sort of prime. The term has also been applied to the composition applied between colours in colour changing stars.

Dartcord Trade name of a linear chevron shaped high explosive charge, containing RDX in a lead sheath.

Date-Shift Code A code applied by manufacturers to the outside shipping containers, and, in many instances, to the immediate containers of explosive materials to aid in their identification and tracing.

Daylight shell A shell designed to be fired in daylight and thus incorporating one or more of the following effects:- noise units (crackers, whistles etc.), smoke, magnesium stars.

DC Direct current.

Dead Pressed In an explosive, a highly compressed condition which tends to prevent the transition from deflagration to detonation that would otherwise take place.

Decaborane [B10H14] This chemical is classed as a flammable solid and is used for rocket fuels. It will remain stable indefinitely at room temperature.

Decant to remove the liquid portion of a settled mixture without disturbing the sediment.

Dechlorane [C10Cl12] White powder used as a chlorine donor (colour enhancer).

Decibel A unit of air overpressure commonly used to measure air blast. The faintest audible sound is arbitrarily assigned a value of 0 dB, and the loudest sounds that the human ear can tolerate are about 120 dB. The difference in decibels between any two sounds is equal to 10 log10 (P1/P2), where P1 and P2 are the two power levels.

Deflagration 1) The chemical decomposition (burning) of a material in which the reaction front advances into the reacted material at less than sonic velocity. 2) Very rapid combustion sometimes accompanied by flame, parks and/or spattering of burning particles. Deflagration, although classed as an explosion, generally implies the burning of a substance with self-contained oxygen so that the reaction zone advances into the unreacted material at less than the velocity of sound in the material. In this case, heat is transferred from the reacted to the unreacted material by conduction and convection. Burning rate usually less than 2,000 meters / second.

Degradable that which can be reduced, broken down or chemically separated.

Degreasing the process of removing greases and oils from sewage, waste, and sludge.

Delay A distinct pause of predetermined time between detonation or initiation impulses, to permit the firing of explosive charges separately. A delay may be mechanical, pyrotechnic, electronic or an explosive train component that introduces a controlled time delay in some element of the arming or functioning of a fuze mechanism.

Delay Detonator An electric or nonelectric detonator used to introduce a predetermined lapse of time between the application of a firing signal and the detonation of the base charge.

Delay Element An explosive train component normally consisting of a primer, a delay column and a relay detonator or transfer charge assembled in that order in a single housing.

Delay fuse A pyrotechnic composition designed to give a delay before functioning the next device in the explosive train. The most common use for a delay fuse is to provide a number of seconds for the operator to retire from the device before it functions. Also the internal delay within a shell used to ignite the bursting charge.

Delay Fuze that has a delay element incorporated in the fuze train permitting the missile to penetrate the target a distance corresponding to the delay. Such fuzes are used to permit penetration of the target before detonation or for mining effect.

Delay Mechanism A mechanism designed to initiate detonation at a predetermined period of time after energy is applied to the ignition system.

Delay Series A series of delay detonators designed to satisfy specific blasting requirements. There are basically two types of delay series: millisecond (MS) with delay intervals on the order of milliseconds, and long period (LP) with delay times on the order of seconds.

Delay Tag A tag, band, or marker on a delay detonator that denotes the delay series, delay period, and / or delay time of the detonator.

Delay Time The lapse of time between the application of a firing signal and the detonation of the base charge of a delay detonator.

Demineralisation removal from water of mineral contaminants. Methods include ion exchange, flash distillation, electro dialysis, or reverse osmosis.

Demolition The breaking up of artificial (man-made) structures by blasting.

Density Of Charge density refers to the mass of an explosive per unit of volume, usually expressed in grams per cubic centimeter or pounds per cubic foot. Density is an important characteristic of an explosive. Raising the density (i.e. by pressing or casting) improves brisance and detonating velocity.

Density The density of a substance is its mass per unit volume. Because many substances, especially gases, can be compressed into a smaller volume by increasing the pressure on them, the temperature and pressure at which the density is measured are usually specified. Specific Gravity. The SI unit of density is the kilogram per cubic meter (kg/m3); the density of aluminum for instance is 2700 kg/m3. Another common unit of density is the gram per cubic centimeter (g/cm3). Since 1kg = 1000g and 1m3 = (100 cm)3 = 106 cm3, 1 g/cm3 = 103 kg/m3. Hence the density of aluminum can also be given as 2.7 g/cm3. Water at 3.98Ý C = 1.000000 grams/ml Water at 3.98Ý C = 0.999973 grams/cm3

Destructor An explosive device for intentionally destroying a missile or aircraft or component thereof.

Deterrent A material applied as a coating on grains of powder to reduce the initial rate of burning.

Detonate or **Detonation** To be changed by exothermic chemical reaction usually from a solid or liquid to a gas with such rapidity that the rate of advance of the reaction zone into the unreacted material exceeds the velocity of sound in the unreacted material; that is, the advancing reaction zone is preceded by a shock wave.

Detonating Agent Explosive used to set off another explosive. Fulminate of mercury and tetryl are generally used as detonating agents, to set off other less sensitive explosives.

Detonating Charge Generally applied to a detonating initiator used to set off a high-explosive charge.

Detonating Cord (DC) Cord, Detonating. A strong flexible cord containing a core of detonating explosive, used primarily for initiating a series of charges. It burns by propagation of a detonating shock wave (typically 5000-7000 metres/sec), when initiated with a Detonator.

Detonating Cord Downline The section of detonating cord that extends within the borehole from the ground surface down to the explosive charge.

Detonating Cord MS Connectors Nonelectric, short-interval (millisecond) delay devices for use in delaying blasts that are initiated by detonating cord.

Detonating Cord Trunkline The line of detonating cord that is used to connect and initiate other lines of detonating cord.

Detonating Explosive High- Explosive.

Detonating Primer A name applied for transportation purposes to a device consisting of a detonator and an additional charge of explosives, assembled as a unit.

Detonating wave The shock wave set up when a detonator is ignited.

Detonation An explosive reaction that moves through an explosive material at a velocity greater than the speed of sound in the material. A detonation is a chemical reaction given by an explosive substance in which a shock wave is formed. High temperature and pressure gradients are generated in the wave front, so that the chemical reaction is initiated instantaneously. Detonation velocities lie in the approximate range of 1,400 to 9,000 m/s = 5,000 to 30,000 ft/s; slower explosive reactions, which are propagated by thermal conduction and radiation, are known as deflagration. A chemical reaction in which the reaction front advances with a speed which exceeds the velocity of sound in the material. In this case, energy is transmitted from the reacted to the unreacted material by a shock wave. Burning rate usually in excess of 2,000 meters / second.

Detonation Front *See Wave Front*.

Detonation Rate Velocity at which the detonation wave travels through an explosive material.

Detonation Velocity The velocity at which a detonation progresses through an explosive.

Detonation Wave The location within an explosive that is undergoing conversion (reaction) at a particular point in time, and which moves at a velocity known as the V.O.D. or Velocity Of Detonation.

Detonation, Low Order A chemical reaction in a detonable material in which the

reaction front advances with a velocity which is appreciably lower than that which is the characteristic detonation velocity for the material in question.

Detonator An explosive train component which can be activated by either a non-explosive impulse or the action of a primer and is capable of reliably initiating high order detonation in a subsequent high explosive component of the train. When activated by a non-explosive impulse, a detonator includes the function of a primer. In general, detonators are classified in accordance with the method of initiation such as percussion, stab, electric, friction, flash chemical, etc. A cap or capsule of sensitive explosive material used to initiate a charge of high explosives. Any device containing any initiating or primary explosive that is used for initiating detonation. A commercial or may not contain more than 10 g of total explosives by weight, excluding ignition or delay charges. The term includes, but is not limited to, electric blasting caps of instantaneous and delay types, blasting caps for use with safety fuses, detonating cord delay connectors, and nonelectric instantaneous and delay blasting caps that use detonating cord, shock tube, or any other replacement for electric legwires. Detonators should not to be confused with a firework igniter, or squib, a detonator is used to initiate high explosives. As such, detonators are security attractive items and their possession is controlled in many countries.

Detonator *Also known as Blasting Cap.*

Dew point the temperature at which the condensation of a vapour begins; the term is usually applied to condensation of moisture from the water vapour in the atmosphere.

Dextrine or dextrin **[(C6H10O5)n]** Beige coloured crystalline powder. Produced from the partial hydrolysis of starch. Generally used as a binder in fireworks although some times used as a cooling agent. Has very good adhesive properties, although no more than about 5% should be added to a dry star mix as it does tend to be rather hydroscopic after mixing with water.

DI water deionised water, having had all the ions removed.

Dialysis the separation of a colloid from a substance in solution by allowing the solution to diffuse through a semi permeable membrane.

Diamond [C] is a mineral, one of two crystalline forms of the element Carbon. It is the hardest substance known, and inferior stones are used as abrasives, in certain types of cutting tools, and as phonograph needles. Gem diamonds were first found in streambeds in India and Borneo; most now come from volcanic pipes in South Africa. Famous diamonds include the Koh-i-noor, now among the English crown jewels; the Cullinan, from which 105 stones were cut; and the blue Hope diamond. Synthetic diamonds, produced since 1955, are now widely used in industry, these are created through the utilization of explosive energy to compress carbon.

Diatomaceous Earth a filter medium used for filtration of effluents from secondary and tertiary treatments, particularly when a very high grade of water for reuse in certain industrial purposes is required; used as an absorbent for oils and oily emulsions in some wastewater treatment designs; also used historically in preparing standard suspensions for turbidity measurements.

Diazoacetic Ester [C4H6N2O2] A very severe explosive in the form of a yellow oil. It will explode on contact with Sulphuric acid or when heated. Very volatile and explosive.

Diazoaminobenzene [C6H5N:N.NH.C5] These golden yellow crystals will explode when heated to 150 degrees.

Dichromation *Material to be added later*

Dielectric *Material to be added later*

Diffraction is the bending of radiation (such as light) around the edge of an obstacle or by a narrow aperture. Diffraction results from the Interference of light waves that pass an opaque body, producing a fuzzy region between the shadow area and the lighted area that, upon close examination, is actually a series of light and dark lines. A diffraction grating contains many fine, parallel slits or scratches (about 12,000 per cm or 30,000 per inch) and disperses light into its colors. These gratings are used in diffracting spectoscopes. The atomic and molecular structure of crystals is examined by X-ray diffraction.

Diluent An additive, usually inert, used to regulate burning rate or temperature the thinning agent used to dilute a fluid, usually water.

Dilute to thin out, or having been thinned out; less than full strength.

Diode A two-terminal device having a low Resistance to electric current in one direction and a high resistance in the reverse direction. Diodes are thus useful as Rectifiers, converting alternating current (AC) into direct current (DC). Although Electron-tube diodes were once common, almost all diodes today are Semiconductor devices. In general, current flowing through a diode is not proportional to the voltage between its terminals. When the voltage applied in the reverse direction exceeds a certain value, a semiconductor diode breaks down and conducts heavily in the direction of normally high resistance. This effect can be exploited to regulate voltage. Some diodes are sensitive to light (Photovoltaic Cell). A light-emitting diode (LED) produces light as current passes through it; some LEDs can act as lasers. A thermistor is a special semiconductor diode whose conductivity increases with the diode temperature.

Direct Current (dc) a non-oscillating current that flows continually in one direction through a circuit

Display area Usually the area in which the rigging of the display takes place (syn. firing area), but more generally the entire area encompassing spectator area, firing area, safety area and fallout area.

Display firework Usually a large firework intended for use at large public/private displays. In the UK it is erroneously synonymous with Category 4 fireworks while in the US it is UN 0335 (1.3G) fireworks.

Distillation process used to separate the substances composing a mixture; it involves a change of state, e.g., liquid to gas, and subsequent condensation . A simple distillation apparatus consists of three parts: a flask in which the mixture is heated, a condenser in which the vapour is cooled, and a vessel in which the condensed vapour, called distillate, is collected. Upon heating, the substances with a higher boiling point remain in the flask and constitute the residue. When the substance with the lowest boiling point has been removed, the temperature can be raised and the process repeated with the substance having the next lowest boiling point. The process of obtaining portions (or fractions) in this way is called fractional distillation. In destructive distillation various solid substances, such as wood, coal, and oil shale, are heated out of free contact with air, and the portions driven off are collected separately. Distillation is used in refining Petroleum and in preparing alcoholic beverages.

Distilled water Is water that has been purified by distillation (boiling the water off as steam and condensing it back to a liquid, leaving the impurities behind). Having been boiled, it is also sterile.

Distribution Series The systematic arrangement of data.

Distruping or **Bursting Explosives** Explosives of this classification are employed to create damage to the target under attack. They are high-explosive charges that are used alone or as part of the explosive charge in mines, bombs, depth charges, missile and torpedo warheads, and in projectiles as a burster charge.

Do's and Don'ts A list of precautions printed by Big Bang Fireworks pertaining to the storage, handling, and use of fireworks.

Doppler Effect is the change in the wavelength (and frequency) of a wave as a result of the motion of either the source or receiver of the waves. If the source and the receiver are approaching each other, the frequency of the wave will increase and the wavelength will be shortened - sounds will be higher in pitch and light will be bluer. If the source and receiver are moving apart, sounds will become lower-pitched, and light will appear redder . Astronomers analyze Doppler shifts of light and radio waves to measure the velocities and (indirectly) distances of remote objects.

DOT Abbreviation for the US Department of Transportation. In the UK the similar department is now called the Department of Environment and the Regions (Abbr. DETR)

DOT classification The assigning of fireworks by the US DOT into one of three classes.

Double-Based Propellant whose principle active ingredients are nitrocellulose and nitroglycerin.

Drag Component of air resistance in the direction opposite to that of the motion of the centre of gravity of a projectile.

Draw-out shell A two break shell in which the first burst is usually colour, the second colour and report.

Driver, Mil. A small unit, similar to an explosive switch, in which a piston is pushed forward by a small explosive and/or propellant charge.

Driver, Fwk. A specialised gerb, usually more powerful tan a gerb used on a static set piece, whose primary purpose is in turning a wheel or similar item. In the past turning cases were invariably gold, usually made with neat blackpowder with the addition of charcoal, and produced very few sparks. Modern drivers often include titanium for additional visual effect.

DTI In the UK the Department of Trade and Industry, responsible for aspects of the sale of fireworks to the general public.

Dual Use (Explosive) An explosive or more specifically an explosive product which is utilized for both civil and military applications.

Dud An explosive device that has failed to initiate as intended.

Dummy Fireworks Product that has no explosive content or charge. Dummys are used for practice and training purposes and as Point of Sale material.

Dwell Time In press loading powders into cavities, the interval of time that the powder is held at the full loading pressure.

Dyes, Organic products used in the production of smokes. The numberous variables in the various dyes, such as particle size, sublimation temperature, impurites etc., require

that compositions may need constant amendments.

Dynamics is a branch of mechanics that deals with the Motion of objects; it may be further divided into kinematics, the study of motion without regard to the forces producing it, and kinetics, the study of the Forces that produce or change motion. The principles of dynamics are used to solve problems involving work and energy, and to explain the pressure and expansion of gases, the motion of planets, and the behavior of flowing fluids (gases and liquids). Special branches of dynamics treat the particular effects of forces and motions in fluids ; these include Aerodynamics, these include the study of gases in motion, and hydrodynamics, the study of liquids in motion.

Dynamite A high explosive used for blasting, consisting essentially of a mixture of, but not limited to, nitroglycerin, nitrocellulose, ammonium nitrate, sodium nitrate, and carbonaceous materials. Invented in 1866 by Alfred B. Nobel, dynamite is usually pressed in cylindrical forms and wrapped in an appropriate material, e.g., paper or plastic. The charge is set off with a detonator.

E

E.C. Smokeless Powder Orange or pink explosive powder, resembling coarse sand. It is used as a charge in small arms, in blank cartridges. Also called blank-fire powder or E.C. Blank Fire.

EBW (Exploding Bridge Wire) A bridgewire designed to be exploded by a high energy discharge rather than being heated by applied power.

EBW Cap Exploding bridge wire cap. Requires a special, high energy blasting machine to initiate EBW caps.

Echo Reflection of a sound wave back to its source in sufficient strength and with a sufficient time lag (at least 0.1 sec) to be separately distinguished by the human ear.

edta titration (edta) ethylenediaminetetraacetic acid (or its salts). A standard method of measuring the hardness of a solution.

EED (Electro-Explosive Device) Any cartridge, squib, igniter, etc., which is initiated by an electric current.

EIG The Explosive Industry Group, of the British Confederation of British Industry. The EIG is not a trade organisation and as such does not actively promote the firework industry. Its primary purpose is liaison with Government on safety and legislative matters.

Elastic Strength Pressure The computed internal gas pressure in a gun which, at the section under consideration, will stress the metal in some layer of the wall tangetially, up to the minimum elastic limit which is prescribed for the metal from which the member is made.

Electric And Magnetic Units used to express the magnitudes of various quantities in electricity and magnetism. Three systems of such units, all based on the Metric System, are commonly used. One of these, the mksa-practical system, is defined in terms of the units of the mks system and has the Ampere of electric current as its basic unit. The units of this system - the Volt, Ohm, Watt, and farad - are those commonly used by scientists and engineers to make practical measurements. The two other systems, now being gradually abandoned, are both based on the cgs system. Electrostatic units (cgs-esu) are defined in a way that simplifies the description of interactions between static electric charges; there are no corresponding magnetic units in this system. Electromagnetic units (cgs-emu), on the other hand, are defined especially for the description of phenomena associated with moving electric charges, i.e., electric currents and magnetic poles.

Electric Blasting Cap A blasting cap designed for and capable of detonation by means of an electric current.

Electric Blasting Circuit An electric circuit containing electric detonators and associated wiring; Series Blasting Circuit, Parallel Blasting Circuit, and Series in Parallel Blasting Circuit.

Electric Circuit can be described as an unbroken path along which an electric current may flow. A simple circuit consists of a voltage source, such as a battery (Cell, in electricity) or a Generator, whose terminals are connected to those of a circuit element, such as a Resistor, through which current can flow. More complex circuits include additional sources or elements and perhaps Switches, so interconnected that, when

appropriate switches are closed, each element is included in a closed path that also contains a source. Series, parallel, and non-series-parallel connections are illustrated in the figure. The effective Resistance of two series-connected resistors is the sum of the individual resistances. The effective conductance (reciprocal of resistance) of two parallel-connected resistors is the sum of the individual conductances.

Electric Detonator A detonator designed for, and capable of, initiation by means of an electric current.

Electric firing The process of firing a display electrically. Many varied systems have been developed ranging from simple "nail boards" to automatic, computer controlled systems.

Electric igniter The preferred term for the device used to ignite pyrotechnics electrically.

Electric match *see Electric igniter*

Electric Primer Metallic device containing a small amount of sensitive explosive or charge of black powder which is actuated by energizing an electric circuit. It is used for setting off explosive or propelling charges.

Electric Squib Commercial flash-fuze device for electrical firing of burning type munitions such as smoke pots. It consists essentially of a small tube sealed with sulphur, crimped rubber or asphalt containing a small charge of powder compressed around a fine resistance wire. There are three types: open end; flash-vented; and closed end.

Electrical Storm An atmospheric disturbance characterized by intense electrical activity, producing lightning strikes and strong electric and magnetic fields.

Electricity describes a class of phenomena arising from the existence of charge. According to modern theory, most Elementary Particles of matter possess charge, either positive or negative. Two particles of like charge, both positive or both negative, repel each other; two particles of unlike charge are attracted (Coulomb's Law). The electric Force between two charged particles is much greater than the gravitational force between the particles. Many of the bulk properties of matter are ultimately due to the electric forces among the particles of which the substance is composed. Materials differ in their ability to allow charge to flow through them. Those that allow charge to pass easily are conductors, whereas those that allow extremely little charge to pass through are called insulators , or Dielectrics. A third class of materials, called Semiconductors, is intermediate. Electrostatics is the study of charges, or charged bodies, at rest. When a positive or negative charge builds up in fixed positions on objects, certain phenomena can be observed that are collectively referred to as static electricity. The charge can be built by rubbing certain objects together, such as silk and glass or rubber and fur; the friction between these objects causes Electrons to transfer from one to another with the result that the object losing electrons acquires a positive charge and the object gaining electrons acquires a negative charge. Electrodynamics is the study of charges in motion. A flow of electric charge constitutes an electric current. In order for a current to exist in a conductor, there must be an Electromotive Force (emf), or potential difference, between the conductor's ends. An electric Cell, a Photovoltaic Cell, and a Generator are all sources of emf. An emf source with an external conductor connected from one of the source's two terminals to the other constitutes an Electric Circuit. Direct current (DC) is a flow of current in one direction at a constant rate. Alternating current (AC) is a current flow that increases in magnitude from zero to a maximum, decreases back to zero, increases to a maximum in the opposite direction, decreases to zero, and then repeats this process periodically. The number of repetitions of the cycle occurring each second is defined as the frequency, which is expressed in Hertz (Hz). The frequency of ordinary household

current in the U.S. is 60 cycles per sec (60 Hz), and electric devices must be designed to operate at this frequency. In a solid, the current consists not of a few electrons moving rapidly but of many electrons moving slowly; although this drift of electrons is slow, the impulse that causes it moves through the circuit, when the circuit is completed, at nearly the speed of light. The movement of electrons in a current is not steady; each electron moves in a series of stops and starts. In a direct current, the electrons are spread evenly through the conductor; in an alternating current, the electrons tend to congregate along the conductor surface. In liquids, gases, and semiconductors, current carriers may be positively or negatively charged.

Electrode An electrode is a terminal, usually in the form of a wire, rod, or plate, through which electric current passes between metallic and nonmetallic parts of an Electric Circuit. The electrode through which current passes from the metallic to the nonmetallic conductor is called the anode; that through which current passes from the nonmetallic to the metallic conductor is called the cathode. An electrode may be made of a metal, e.g., copper, lead, platinum, silver, or zinc, or of a nonmetal, commonly carbon.

Electrolysis The passage of an electric current through a conducting solution or molten salt (either is a type of Electrolyte that is decomposed in the process. When a cathode, or negative electrode, and an anode, or positive electrode, are dipped into a solution, and a direct-current source is connected to the electrodes, the positive ions migrate to the negative electrode and the negative ions migrate to the positive electrode. At the negative electrode each positive ion gains an electron and becomes neutral; at the positive electrode each negative ion gives up an electron and becomes neutral. The migration of ions through the electrolyte constitutes the electric current flowing from one electrode to the other. Electrolysis is used in the commercial preparation of various substances, e.g., chlorine by the electrolysis of a solution of common salt, and hydrogen by the electrolysis of water. The electrolysis of metal salts is used for plating.

Electrolyte An electrical conductor in which current is carried by Ions rather than free electrons (as in a metal). Electrolytes include water solutions of acids, bases or salts; certain pure liquids; and molten salts.

Electromagnet A device in which an electric current, passing through a wire coil wrapped around a soft iron core, produces a magnetic field. The magnetic-field strength produced depends on the number of turns of the coil of wire, the size of the current, and the magnetic permeability of the core. Electromagnets lose their magnetism when the current is discontinued

Electromagnetic Radiation is energy radiated in the form of a Wave caused by an electric field interacting with a magnetic field. Electromagnetic radiation is the result of the acceleration of a charged particle. It does not require a material medium, and can travel through a vacuum. The theory of electromagnetic radiation was developed by James Clerk Maxwell and published in 1865, although his ideas were not accepted until Heinrich Hertz proved the existence of radio waves in 1887. In order of decreasing wavelength and increasing frequency, the various types of electromagnetic radiation are Radio waves, Microwaves, Infrared Radiation, visible Light, Ultraviolet Radiation, X-Rays, and Gamma Radiation. The possible sources of electromagnetic radiation are directly related to wavelength; long radio waves are produced by large antennas such as those used by broadcasting stations; much shorter visible light waves are produced by the motions of charges within atoms; the shortest waves, those of gamma radiation, result from changes within the nucleus of the atom. The individual quantum of electromagnetic radiation is known as the Photon.

Electromotive Force (emf) is the difference in electric Potential, or voltage, between the terminals of a source of electricity. It is usually measured in Volts.

Electron An electron is an Elementary Particle carrying a unit charge of negative electricity. An Atom consists of a small, dense, positively charged nucleus surrounded by electrons that whirl about it in orbits, forming a cloud of charge. Ordinarily there are just enough negative electrons to balance the positive charge of the nucleus, and the atom is neutral. If electrons are added or removed, a net charge results, and the atom is said to be ionised Atomic electrons are responsible for the chemical properties of matter (Valence). The electron was discovered in 1897 by Joseph John Thomson, who showed that cathode rays are composed of electrons. The electron is the lightest known particle having a non-zero rest mass. The positron, the electron's antiparticle (Antimatter), was discovered in 1932.

Electron Tube device consisting of a sealed enclosure in which electrons flow between Electrodes separated either by vacuum (in a vacuum tube) or by an ionised gas at low pressure (in a gas tube). The two principal electrodes of an electron tube are called the anode and cathode. The simplest vacuum tube, the Diode, contains only these two electrodes. When the cathode is heated, it emits a cloud of electrons, which are attracted to the positive polarity of the anode and constitute the current through the tube. Because the anode is not capable of emitting electrons, no current can flow in the reverse direction, and the diode acts as a Rectifier. In the vacuum triode, small signals applied to a third electrode, called a grid, placed between the cathode and anode cause large fluctuations in the current between the cathode and anode. A triode can thus act as a signal Amplifier. Although formerly the key elements of Electric Circuits, electron tubes have been almost entirely displaced by Semiconductor devices.

Electrostatic Sensitivity The tendency of a composition to ignite (usually accidentally) from the energy supplied by an electric spark.

Element a substance that cannot be resolved into two or more other substances; a substance made up of atoms with the same atomic number.

Elementary Particles are tiny bits of matter assumed to be the most basic constituents of the universe. Certain elementary particles combine to form an Atom, which is the basic unit of any chemical Element and from which all forms of matter are built. The first elementary particle to be discovered was the Electron, identified in 1897 by Joseph John Thomson. The nucleus of ordinary hydrogen was subsequently recognized as a single particle and was named the Proton. The third basic particle in an atom, the Neutron, was discovered in 1932. Although models of the atom consisting of just these three particles are sufficient to account for all forms of chemical behaviour of matter, Quantum Theory predicted the existence of additional elementary particles. A search for the positron, or antiparticle (Antimatter) of the electron, led to its detection in 1932, but a search for a particle predicted by Yukawa Hideki in 1935 led to the unexpected discovery of the mu meson, or muon, the following year. Yukawa's particle was finally discovered in 1947 and named the pi meson, or pion. Both the muon and the pion were first observed in Cosmic Rays. As the list of particles and antiparticles grew, through further study of cosmic rays and the study of the results of particle collisions produced by Particle Accelerators, four basic categories of particles were distinguished, according to their behaviour with regard to the four fundamental forces of nature: gravitational, electromagnetic, strong nuclear, and weak nuclear. A given particle experiences certain of these forces but may be immune to others. The gravitational force is experienced by all particles. The electromagnetic force is experienced only by charged particles, although it is transmitted by the Photon, which has no charge. The weak and strong nuclear forces exist only at the atomic level. Of the four classes of particles, the smallest is that of the massless bosons, which include the photon, eight types of gluons, and the hypothetical graviton. The lepton class includes twelve particles: the electron, the positron, the positive and negative muons, the tauon and its antiparticle, and the neutrino or antineutrino associated with each of these particles. The bosons and the leptons are not strongly interacting. Members of the meson class are more massive than the leptons. The mesons

are the "glue" that holds nuclei together. By far the largest class of particles is the baryon class, the lightest members of which are the proton and neutron; the heavier members are the hyperons. Baryons and mesons, both strongly interacting, are sometimes considered together as hadrons. A theory independently proposed in 1964 by Murray Gell-Mann and George Zweig explains the properties of all known hadrons according to the assumption that hadrons are built up of other, still more fundamental particles called Quarks.

Ellipse *Material to be added later*

Emulsion a liquid system in which one liquid is finely dispersed in another liquid in such a manner that the two will not separate through the action of gravity alone.

Emulsion Explosive An explosive material containing substantial amounts of oxidizers dissolved in water droplets surrounded by an immiscible fuel:

End Burning *Material to be added later*

End point that stage in the titration at which an effect, such as a colour change, occurs, indicating that a desired point in the titration has been reached.

Endothermal

Energy is whatever can be efficiently converted into heat or motion to provide power to run machines and vehicles and to supply heat and light. Energy sources are of two basic types, renewable and nonrenewable. Most of the industrial world is presently powered by nonrenewable fossil fuels - coal, Petroleum, and Natural gas - that, once used, cannot be replaced. Fission Nuclear reactors are fueled by uranium or plutonium, themselves finite energy sources. Spent uranium, however, can be converted to fissile plutonium in a breeder reactor, a process that makes nuclear energy almost infinitely renewable. Nuclear technology, however, has not yet developed either failproof reactors or a safe method for disposing of nuclear wastes. The development of nuclear fusion (whose end products are harmless) has so far been hindered by the difficulties of containing the fuels (plentiful light elements such as hydrogen) at the extremely high temperatures necessary to initiate and sustain fusion. Renewable energy sources include the energy from water and wind (i.e. turbines; water wheels and windmills); geothermal energy, the earth’s internal heat that is released naturally in geysers and volcanoes; tidal energy, the power released by the ebb and flow of the ocean’s tides; biomass, the use of certain crops (including wood) or crop wastes either directly as fuel or as a fermentable source of fuels such as alcohol or methane; and Solar energy, which can be stored and used directly as heat, or transformed into electricity through the use of Photovoltaic cells. All these renewable energy sources are presently being tapped in some form, but none can replace fossil fuels without huge advances in the technologies needed to exploit them.

English Units Of Measurement is the principal system of a few nations, the only major industrial one being the United States. The English system actually consists of two related systems-the U.S. Customary System, used in the United States and dependencies, and the British Imperial. Great Britain, the originator of the latter system, is now gradually converting to the Metric System. The names of the units and the relationships between them are generally the same in both systems, but the sizes of the units differ, sometimes considerably. The basic unit of length is the yard (yd); the basic unit of mass (weight) is the pound (lb). Within the English units of measurement there are three different systems of weights (avoirdupois, troy, and apothecaries’), of which the most widely used is the avoirdupois. The troy system (named for Troyes, France, where it is said to have originated) is used only for precious metals. Apothecaries’ weights are based on troy weights; in addition to the pound, ounce, and grain - which are equal to the troy units of the same name - other units are the dram and the scruple.

For liquid measure, or liquid capacity, the basic unit is the gallon. The U.S. gallon, or wine gallon, is 231 cubic inches (cu in.); the British imperial gallon is the volume of 10 lb of pure water at 62ÝF and is equal to 277.42 cu in. The British units of liquid capacity are thus about 20% larger than the corresponding American units. The U.S. bushel, or Winchester bushel, is 2,150.42 cu in. and is about 3% smaller than the British Imperial bushel of 2,219.36 cu in.; a similar difference exists between U.S. and British subdivisions. The barrel is a unit for measuring the capacity of larger quantities and has various legal definitions depending on the substance being measured, the most common value being 105 dry quarts. Since the Mendenhall Order of 1893, the U.S. yard and pound and all units derived from them have been defined in terms of the metric units of length and mass, the meter (m) and the kilogram (kg); since 1959 these values are 1 yd = 0.9144 m and 1 lb = 0.45359237 kg.

Enthalpy In thermodynamics, a term meaning total heat energy.

Environmental Testing Tests referring to exposure of items to climatic, mechanical and other external stresses.

Enzyme An enzyme is a protein functioning as a biological Catalyst. Enzymes accelerate (often by several orders of magnitude) chemical reactions in the cell that would proceed imperceptibly or not at all in their absence. The enzyme is not permanently modified by its participation. Most enzymes demonstrate great specificity, reacting with only one or a small group of closely related chemical compounds; thus, sometimes several enzymes are required for efficient catalytic function. Some enzymes depend on the presence of Coenzymes for their function. For the enzyme to continue to be effective, its three-dimensional molecular structure must be maintained. X-ray crystallography is used to analyse the structure of enzymes. Over 1,000 different enzymes have been identified, and the exact sequence of Amino Acids (subunits of a protein) has been determined for many proteins since 1967, when the first such determination was made. It is believed that enzymes function by attaching the substrate molecule to a specific molecular site, so that the electrostatic forces of nearby atoms sharply reduce the energy needed to cleave and re-form the appropriate chemical bonds.

Equal Section Charge Propelling charge made up of a number of charges equal in size. The number of sections used determines the muzzle velocity and range of the projectile.

Equation Of State An equation relating the volume, temperature and pressure of a system.

Erosion 1) In a solid rocket, the wearing away of the propellant due to heat, radiation and gas velocity.

2) Wearing away of a bore due to combined effect of gas washing, scouring and mechanical abrasion.

Escape Velocity The radial speed which a particle or larger body must attain in order to escape from the gravitational field of a planet or star.

Ethanol or ethyl alcohol **[CH3CH2OH],** a colourless liquid with characteristic odour and taste, commonly called grain alcohol or, simply, Alcohol. Ordinary ethanol is about 95% pure, the remaining 5% being water, which can only be removed with difficulty to give pure or absolute ethanol. Ethanol is the alcohol in beer, wine, and liquor, and can be made by the fermentation of sugar or starch. Denatured alcohol, for industrial use, is ethanol with toxic additives. Ethanol is used as a solvent in the manufacture of varnishes and perfumes; as a preservative; in medicines; as a disinfectant; and as a fuel. Ethanol is a soporific; if its presence in the blood exceeds about 5%, death usually occurs. Behavioural changes, impairment of vision, or unconsciousness occur at lower

concentrations.

Ether Ethere or aether, in physics, a hypothetical medium for transmitting Electromagnetic radiation, filling all unoccupied space. The theory of Relativity eliminated the need for such a medium, and the term is used only in a historical context.

European standard A proposed standard (CEN 212) for consumer fireworks in the EU The standard is due to come into force in sometime this century!.

Exosphere The outermost, or topmost, position of the atmosphere.

Exothermal A process characterized by the evolution of heat.

Expansion Ratio In rocketry, the ratio of nozzle exit area to the nozzle throat area.

Expelling Charge Quantity of propellant used in special purpose shell to eject the contents of the shell.

Explode To be changed in chemical or physical state usually from a solid or liquid to a gas (as by chemical decomposition or sudden vaporization) so as to suddenly transform considerable energy into the kinetic form. To be changed in chemical or physical state, usually from a solid or liquid gas (as by chemical decomposition or sudden vaporization) so as to suddenly transform considerable energy into the kinetic form Explosion.

Exploder An alternative term for a fuze, usually used in connection with torpedoes.

Exploding Bridge Wire EBW.

Explosion A chemical reaction or change of state with the generation and extremely rapid expansion of gases, usually associated with the liberation of heat. An explosion produces a shock wave in the surrounding medium. A rapid chemical reaction with the generation of high temperature and usually a large quantity of gas.

Explosive The term explosive includes any chemical compound or mechanical mixture which, when subjected to heat, impact, friction, detonation or other suitable initiation, undergoes a very rapid chemical change with the evolution of large volumes of highly heated gases which exert pressures in the surrounding medium. The term applies to materials that either detonate or deflagrate.

Explosive Actuated Device Any tool or special mechanized device that is actuated by explosives. The term does not include propellant-actuated devices. (Propellant-Actuated Power Device.)

Explosive Bolt A bolt that is intended to be fractured at a predetermined point by a contained or inserted explosive charge for the purpose of releasing a load.

Explosive Charge The quantity of explosive material used in an explosive device, or in industrial applications refers to explosive material in a blast-hole, coyote tunnel, or other form of placement.

Explosive Compounds Explosive substances may be classified by their reaction, composition, or service use. Military explosives are divided into two general classes, high explosives and low explosives, according to their rates of decomposition. They may be further classified according to use. From the standpoint of their composition, explosives may be divided into explosive mixtures and explosive compounds. Classification of explosives thus far has been based on characteristics.

Explosive D Ammonium picrate, a high explosive charge that is not easily set off in transportation or in handling, etc. Sometimes it is used as a bursting charge in armour-piercing projectiles.

Explosive Entry The utilization of explosive devices to facilitate access into a target area through a conventional or non-conventional breach point.

Explosive Materials These include explosives, blasting agents and detonators. This term includes, but is not limited to, dynamite and other high explosives, slurrys, emulsions, water gels, blasting agents, black powder, pellet powder, initiating explosives, detonators, safety fuses, squibs, detonating cord, igniter cord, igniters, pyrotechnics, pyrotechnic compositions, fireworks (special and common), ammunition, propellent and propellent compositions.

Explosive Mixtures

Explosive Nut A nut that is intended to be fractured by a contained or inserted explosive charge for the purpose of releasing a load.

Explosive Oils Sensitive liquid explosives such as nitroglycerin, ethylene glycol dinitrate, and metriol trinitrate.

Explosive Strength The amount of energy released by an explosive upon detonation that is an indication of the capacity of the explosive to do work.

Explosive Substance which, when subjected to heat, impact, friction or other suitable initial impulse, undergoes an explosion that is a very rapid chemical transformation, forming other more stable products entirely or largely gaseous, whose combined volume is much greater than that of the original substance. Explosives are classified as high-explosive or low-explosive, according to the rate of transformation. Any chemical compound, mixture, or device, the primary or common purpose of which is to function by explosion.

Explosive Switch A self-contained electrically initiated small unit which causes one or more electric circuits to be opened and / or closed by "explosive" (actually propulsive) action.

Explosive technically - any material that is capable of undergoing a self-contained and self-sustained exothermic chemical reaction at a rate that is sufficient to produce substantial pressures on their surroundings thus causing physical damage. ALL fireworks are classified as explosives.

Explosive Train An arrangement of a series of combustible and explosive elements consisting of a primer, a detonator, a delay, a relay, a lead and booster charge, one or more of which may be either combined with another element or omitted. The function of the explosive train is to accomplish the controlled augmentation of a relatively small impulse into one of sufficient energy to cause the main charge of the munition to function. A train of combustible and explosive elements arranged in order of decreasing sensitivity. The explosive train accomplishes the controlled augmentation of a small impulse into one of suitable energy to actuate the main charge. For instance within a hand-lit shell the train is Delay Fuse->shell leader->lifting charge->shell delay->bursting charge->star prime->star

Explosive Wave A wave of chemical action which passes through an explosive substance when it explodes; also, more accurately, detonation zone.

Exterior Ballistics The branch of ballistics which deals with the motion of the projectile after it leaves the gun.

Extraneous Electricity Electrical energy, other than actual firing current or the test current from a blasting galvanometer, that is present at a blast site and that could enter an electric blasting circuit. It includes stray current, static electricity, RF (electromagnetic) waves, and time-varying electric and magnetic fields.

F

F.A.E. (Fuel Air Explosive) A chemical which will detonate when mixed with ambient air which is required to maintain the detonations oxygen balance. An example is propylene oxide.

Fallout Area The area designated for debris to fall at a firework display. Obviously the position and size of the fallout area are critically dependent on the wind direction and strength at the time of the display. Careful planning at the design stage must allow for variations in the fallout area and position.

FCA Fuse/Cap Assembly

Feasibility Study A much misused and over-used term to denote the determination of the practicability, advisability or adaptability of an item or technique for an intended purpose.

Ferro-Titanium An alloy of Iron and Titanium which is finding increasing use in firework manufacture. Different ratios of Fe:Ti are available although generally all burn with a much more silver flame than Fe alone, best for fountains or comets.

Fertilizer A fertilizer may be an organic or inorganic material added to the soil to replace or increase plant nutrients. Organic fertilizers - including animal and green manure, fish and bone meal, guano (seabird excrement), and compost - are decomposed by soil microorganisms, and their elements are freed for plant use. Most inorganic or chemical fertilizers contain the major nutrients (nitrogen, phosphorus, and potassium) in proportions required by the crop. Properly used, fertilizers increase crop yields; they do not affect a crop’s nutritive properties unless specifically intended to do so.

Field Expedient A material or technique which can be put together or operated from available materials and simple descriptions in emergencies especially behind lines or in guerrilla warfare.

Filtration the process of separating solids from a liquid by means of a porous substance through which only the liquid can pass.

Fin A fixed or adjustable vane or airfoil affixed longitudinally to an aerodynamically or ballistically designed body for stabilizing purposes.

Fin Stabilization Method of stabilizing a projectile, bomb or missile during flight by the fitting of fins.

Finale barrage A rapid firing, pre-fused, sequence (usually of aerial fireworks) that is typically fired at the end of a display.

Firecracker *see Cracker*

Firework Technically an explosive assigned one of five UN numbers (0333->0337). A device which is designed for entertainment and that comprises pyrotechnic composition.

Fireworks A common synonym for Pyrotechnics.

Firing area The best term for the actual area of firing (rather than display area)

Firing Current An electric current of recommended magnitude and duration to sufficiently energize an electric igniter or a circuit of electric detonators.

Firing Device Any item designed to initiate by mechanical means a blasting cap or an igniter.

Firing Line The wire(s) connecting the electrical power source with the electric blasting circuit.

First Fire The igniter composition used with pyrotechnic devices that is loaded in direct contact with the main pyrotechnic charge. A pyrotechnic first fire composition is compounded to produce a high temperature and hot slag. The composition must be readily ignitable and capable of igniting the underlying pyrotechnic charge. It is not synonymous with prime/priming.

Fix Old English term for a gerb which often included a "bounce".

Fixed Ammunition *Material to be added later*

Fixed Round Round of fixed ammunition.

Flame A chemical reaction or reaction product, partly or entirely gaseous, that yields heat and light. State of blazing combustion. A flame profile is a temperature profile of any particular flame.

Flame Temperature Adiabatic Flame Temperature.

Flammability The ease with which an explosive material may be ignited by flames and heat.

Flanked Usually applied to racks or mortars or Roman candles on a frame in which 3 tubes are angled to produce a dispersed effect.

Flare A pyrotechnic device used to produce a single source of intense light or radiation for relatively long durations for target or airfield illumination, signalling or other purposes. In the UK the term is often applied to distress signals. In the US this is typically a tube, similar to a large lance.

Flash paper A form of nitrocellulose, easily ignited and used to produce a puff of flame.

Flash Point The lowest temperature at which vapours from a volatile combustible substance ignite in air when exposed to flame, as determined in an apparatus specifically designed for such testing.

Flash powder An extremely powerful pyrotechnic composition, typically made from Potassium perchlorate (or rarely pot. chlorate) and powdered aluminium (or magnesium). In fireworks flash powder is often used for powerful maroon shells, ad for bursting colour shells.

Flash Reducer Any material for use with a propelling charge to reduce its muzzle flash.

Flash rocket A rocket that usually only contains flash powder as its payload and thus functions with a loud report and a flash. Flash rockets should never be fired in multiples from cones for risk of detonation. Flash rockets are often used for bird scaring.

Flashover The sympathetic detonation between explosive charges.

Flat Trajectory with little curvature produced by a projectile with a high velocity.

Flechette *(French, "a small arrow")*
1) An aerial dart.

2) A small fin stabilized missile, a large number of which can be loaded in artillery canister.

3) Stabilized fragment having a pointed nose and finned tail.

Flight rocket Usually a small calibre (approx. 14mm) rocket fired in a large number simultaneously from a rocket cone or rocket frame.

Flitter A spark effect (usually silver/gold) produced by the incorporation of relatively coarse metal powders (usually aluminium). the glitter effect is similar but distinctly different.

Floatation the process of removing finely divided particles from a liquid suspension by agitating the liquid with gas bubbles thus increasing the buoyancy of the particles, and concentrating them at the surface of the liquid medium.

Floc a very fine, fluffy mass formed by the aggregation of fine suspended particles.

Flour Traditional flour and water paste has know been superceeded by modern day adhesives. Sometimes used to reduce the burning speed of compositions.

Flower pot A shell malfunction in which the shell bursts within the mortar propelling the shell contents upwards as if from a mine. Also known as a Muzzle break

FLSC (Flexible Linear Shaped Charge) A flexible detonating fuse which is specially shaped to produce a cutting jet. *Linear version of shaped charge*.

Fluid a substance which yields readily to any force which tends to alter its shape; fluids possess no definite shape; the term includes both liquids and gases.

Fluid Mechanics A branch of Mechanics dealing with the properties and behaviour of fluids, or substances that flow, i.e., liquids and gases. The larger part of the field is fluid dynamics (study of fluids in motion), which itself is divided into hydrodynamics (study of liquids in motion) and Aerodynamic (study of gases in motion).

Flux a material used to promote joining of metals in soldering.

Flying saucer An unusual firework device, usually constructed from a ring of plastic or wood, with turning cases and lifting cases. The functioning of the device usually involves rotation around a vertical axis, followed by ascent into the air. "Double acting" saucers fall and then re-ascend to the crowd's delight!

Force A term convenient in interior ballistic theory, which is defined as the product of the number of moles of gas per gram of propellant and the adiabatic-constant-volume flame temperature. The term force comes from the Latin word for "strength". In physics, force is defined by Newton's laws of motion and a force is considered that which can impose a change of velocity on a material body. In physics, force is described as a quantity that produces a change in the size or shape (Strength Of Materials) or the Motion of a body. Commonly experienced as a "push" or "pull," force is a vector quantity, having both magnitude and direction. Four basic types of force are known in nature. The gravitational force (Gravitation) and the electromagnetic force (Electricity; Magnetism) both have an infinite range. The strong nuclear force, or strong interaction, is a short-range force holding the atomic nucleus together, and the weak nuclear force, or weak interaction, is a short-range force associated with radioactivity and particle decay. Scientists have not

been able to confirm the existence of a hypothesized fifth force, a very weak force supposed to counteract gravitation. In the Metric System forces are measured in such units as the dyne (cgs system) and the newton (mks system), which cause accelerations of, respectively, 1 cm/sec2 on a 1-gram mass and 1 m/sec2 on a 1-kg mass. In English Units Of Measurement the pound (lb) is used. A 1-lb force equals 444,823 dynes; 1 dyne equals 10-5 newtons. Force = Mass X Acceleration

Force Cone Tapered beginning of the lands at the origin of the rifling of a gun tube. The forcing cone allows the rotating band of the projectile to be gradually engaged by the rifling thereby centring the projectile in the bore.

Form Coefficient Factor used in form functions to describe the ratio of burning surface to fraction burned.

Form Function Mathematical expression relating burning rate to propellant grain geometry.

Formaldehyde or methanal **[HCHO]**, a colourless, flammable, poisonous gas with a suffocating odour. Pure gaseous formaldehyde is uncommon, because it readily polymerizes into solid paraformaldehyde. Formalin, a 40% by volume solution of formaldehyde in water, is used as an antiseptic, disinfectant, and preservative for biological specimens. Also used in resin-bonded pyrotechnic compositions, very popular in the UK thoughout the 70's and early 80's.

Formula an expression of chemical composition, using symbols and figures.

Fountain A device comprising pyrotechnic composition charged into a tube which may or may not be choked. The composition may be hand charged, or more commonly nowadays, machine charged.

Fragmentation The breaking and scattering in all directions of the pieces of a projectile, bomb or grenade. The breaking of a solid mass into pieces by blasting.

Francium [Fr] radioactive element, discovered in 1939 by Marguerite Perey as a disintegration product of actinium. Some of the 21 known isotopes of this Alkali Metal are prepared by bombarding thorium with protons, deuterons, or alpha particles.

Frangible A material which breaks into a powder or small fragments.

Free-Standing Grain A solid propellant grain which is molded or extruded prior to loading into a rocket case.

Freon trade name for any of a special class of chemical compounds used as refrigerants, aerosol propellants, and solvents. Freons Hydrocarbon derivatives that contain fluorine and often chlorine and bromine as well. They are generally colourless, odourless, non-toxic, non-corrosive, and non-flammable. Though usually un-reactive, freons are now suspected to undergo reactions in the upper atmosphere that may damage the earth's Ozone layer. The most commonly used is Freon-12, or dichlorodifluoromethane (CCl2F2).

Friction Resistance offered to the movement of one body past another body with which it is in contact. The amount of friction depends on the nature of the contact surfaces and on the magnitude of the force pressing the two bodies together, but not on the surface area of the contact surface. The coefficient of friction is the ratio of the force necessary to move one body horizontally over another at a constant speed to the weight of the body. Fluid friction, observed in the flow of liquids and gases, is minimized in airplanes by a modern, streamlined design (Aerodynamics).

Friction Sensitivity The tendency for a composition to ignite as the result of frictional energy (i.e. rubbing).

Front Usually an arrangement of fountains, mines, set pieces or Roman candles along a line parallel to the spectators and fired simultaneously.

Fuel A substance that may react with oxygen to produce combustion. In pyrotechnics, anything combustible such as sulphur, aluminium powder, iron powder, plastic binder; opposite: oxidizer.

Fuel Cell An electric cell in which the chemical energy from the oxidation of a gas fuel is converted directly to electrical energy in a continuous process. In the hydrogen and oxygen fuel cell, hydrogen and oxygen gas are bubbled into separate compartments connected by a porous disk through which an Electrolyte, such as aqueous potassium hydroxide (KOH), can pass. Inert graphite electrodes, mixed with a catalyst such as platinum, are dipped into each compartment. When the two electrodes are electrically connected, an Oxidation and reduction reaction takes place in the cell: hydrogen gas is oxidized to form water at the anode; electrons are liberated in this process and flow through the external circuit to the cathode, where the electrons combine with the oxygen gas and reduce it. Fuel cells have been used to generate electricity in spacecraft.

Fuel In a pyrotechnic composition that which the oxidant oxidises. Common fuels include charcoal, sulphur, aluminium and magnalium. All common pyrotechnic compositions contain at least an oxidant and a fuel.

Fumes The gaseous products of an explosion. For the purpose of fume classification, only poisonous or toxic gases, such as carbon monoxide, hydrogen sulphide, and nitrogen oxides are considered.

Functional Group A functional group in organic chemistry is a group of atoms within a molecule that is responsible for certain properties of the molecule and reactions in which it takes part.

Functioning Time In an EED, the lapsed time between application of initiating energy and some later function such as bridgewire break, case opening or start of pressure rise, peak pressure, etc.

Funnel and wire One method of charging tubes with firework composition.

Fuse An igniting or explosive device in the form of a string or tube which contains a pyrochemical mixture.

Fuse Cap (*Fuse Detonator*) A detonator that is initiated by a safety fuse; also referred to as an ordinary blasting cap.

Fuse Cover The protective cover for the initial fuse of a firework. Often coloured to aid identification in the dark.

Fuse Cutter A mechanical device for cutting safety fuse clean and at right angles to its long axis.

Fuse Lighters Special devices for the purpose of igniting safety fuse.

Fuse or Fuze? The generic term, for the means of transferring fire, to a pyrotechnic product, or from one part of the product to another. Here at Big Bang we refer to "fuse" as a convientional pyrotechnic train, but "fuze" as any electrical ignition source. Unfortunately this is not always the view point of everyone in the pyrotechnic trade

worldwide, where a mixture of both spellings can occur in one document.

Fuse, Delay Any fuse incorporating a means of delaying its action. Delay fuses are classified according to the length of time of the delay. Fuse Lighters Pyrotechnic devices for the rapid and certain lighting of safety fuse.

Fusee A long duration flare, usually red, which may be used as a warning flare on the highway or railway. Fusees may also be used to light fireworks, similar to matches. *See Portfire*

Fuze a protective device containing a short piece of wire that melts and breaks when current through it exceeds a rated value, thus de-energizing the circuit. Device with explosive or pyrotechnic components designed to initiate a train of fire or detonation in a munition.

G

Gallic Acid [C7H6O5.H2O]. Fine colourless needle-like powder, also known as Trihydroxybenzoic Acid. Used in the manufacture of pyrotechnic whistles. Very sensitive to impact and friction.

Gamma Radiation is emitted in one of the three types of natural Radioactivity. It is the most energetic form of Electromagnetic Radiation, with a very short wavelength of less than 10-10 meters. Gamma rays are essentially very energetic X-Rays emitted by excited nuclei. They often accompany alpha or beta particles, because a nucleus emitting those particles may be left in an excited (higher-energy) state. Gamma-ray sources are used in medicine for cancer treatment and for diagnostic purposes, and in industry for the inspection of castings and welds.

Garden firework A firework, usually of limited power and composition weight, intended to be used in restricted areas outdoors.

Gas a fluid having neither independent shape nor volume, but tending to expand indefinitely.

Gas Generator A device in which a propellant is burned to produce a sustained flow of pressurized gas.

Gas Laws describing the behavior of a gas (see States Of Matter) under various conditions of volume (V), pressure (P), and absolute, or Kelvin, Temperature(T). Boyle's, or Mariotte's, gas law states that under constant temperature PV = k1. Charles', or Gay-Lussac's, law states that under constant pressure V = k2T. A third law states that under constant volume P = k3T. The constants k1, k2 , and k3 are dependent on the amount of gas present and, respectively, on the temperature, pressure, and volume of the gas. These three laws can be combined into a single law, or equation of state: PV = kT or Pv = RT, in which v is the specific volume equal to V/n, n is the number of moles of the gas, k is a proportionality constant, and R is the universal gas constant, equal to 8.3149 + 103 joules/kg-mole-degree in mks units. These laws are formulated for so-called ideal or perfect gases. Real gases are described more accurately by the van der Waals equation: (P + a/v2) (v - b) = RT , in which (a) and (b) are specific constants for each gas.

Gasoline is a light, volatile fuel oil, called petrol in Britain. A mixture of Hydrocarbons obtained in the fractional Distillation and "cracking" of Petroleum, it is used as a fuel for internal-combustion engines, for cooking, and as a solvent. The quality of gasoline used in engines is rated by Octane Number. To increase octane rating, lead additives were once widely used.

Gauge Wire A series of standard sizes such as the American Wire Gauge (AWG), used to specify the diameter of wire.

Gauge 1) A measure. The dimensions of a part being machined, the amount of liquid in a container, steam pressure, etc. 2) The size of the bore of a firearm, especially of a shotgun, as determined by the number per pound of spherical projectiles fitting the bore.

Gelatin *Material to be added later*

Generator An electrical device used to convert mechanical energy to electrical energy. It operates on the principle of electromagnetic Induction. The generator moves a conductor through a magnetic field and directs the current produced by the induced voltage to an external circuit. In the simplest generator, the conductor is an open coil of wire rotating between the poles of a permanent magnet. During a single rotation, one side of the coil

passes through the magnetic field first in one direction and then in the other, so that the induced current is alternating current (AC), moving first in one direction, then in the other. Each end of the coil is attached to a separate metal slip ring that rotates with the coil. Brushes resting on the slip ring pass the current to the external circuit. To obtain direct current (DC), i.e., current that flows in only one direction, a commutator is used in place of slip rings. The commutator is a single slip ring split into left and right halves that are insulated from each other and attracted to opposite ends of the coil. Current leaves the generator through the brushes in only one direction and pulsates from no flow to maximum flow and back again. In practice, generators have many coils and several magnets. The whole assembly carrying the coils is called the armature, or rotor; the stationary parts constitute the stator. Except for magnetos, which use permanent magnets, AC and DC generators use electromagnets. AC generators are often called alternators.

Gerb Usually a relatively thick-walled tube filled with composition and having a choke. A gerb functions by throwing out a shower of sparks. From French - gerb - sheaf of corn.

Gilsonite. (asphaltum). Type of carbon fuel.

Girandole *see Flying saucer*

Glass Powder Has been used in match head and striker compositions.

Glitter An effect that produces drossy droplets of molten composition which reach with the air to produce a sparkling or glittering effect that is not as distinct as a strobe effect. Similar but distinct from flitter.

Glow Plugs Inserts containing high resistance wire which attain high incandescent heat when current is passed through the wires. The heat is sufficient to ignite some propellant combinations.

Glue Used traditionally in match heads and sparklers, also as a cooling product in some smoke compositions. Now generally being replaced with the tougher and more elastic PVA and EVA emulsion adhesives.

Glutinous rice starch A binding agent much favoured by Japanese star makers

Grain A single mass of solid propellant regardless of size or shape of the final geometric configuration as used in a gas generator or rocket motor.

Grain, Free Standing A solid propellant grain which is moulded or extruded prior to loading into a rocket case.

Grains A system of weight measurement where 7,000 grains are equivalent to one standard 16-ounce pound (0.45 kg).

Gram Metric unit of weight, unfortunately, no generally adapted abbreviation exists; gm or g are most frequently used.

Granulation Size and shape of grains of pyrotechnic or propellant ingredients.

Grist *Material to be added later*

Graphite A very fine black/grey powder, greasy, and soft, with a metallic luster, it is a good conductor of electricity. Used mainly in compositions in pressing into various moulds to ease their release. Also used as a polish on commercial gunpowder grains. Graphite, also known as plumbago or black lead is a mineral.

Gravitation is the attractive Force existing between any two particles of matter. Because this force acts throughout the universe, it is often called universal gravitation. Isaac Newton was the first to recognize that the force holding any object to the earth is the same as the force holding the moon and planets in their orbits. According to Newton's law of universal gravitation, the force between any two bodies is directly proportional to the product of their Masses and inversely proportional to the square of the distance between them. The constant of proportionality is known as the gravitational constant (symbol G) and equals 6.670 + 10-11 newton-M2/kg2 in the MKS System of units. The measure of the force of gravitation on a given body on earth is the Weight of that body. In the general theory of Relativity, gravitation is explained geometrically: matter in its immediate neighbourhood causes the curvature of the four-dimensional Space-Time continuum.

Greek Alphabet Alpha, Beta, Gamma, Delta, Epsilon, Zeta, Eta, Theta, Upsilon, Iota, Phi, Kappa, Chi, Lambda, Psi, Mu, Omega

Greek fire Used in combat, Greek fire was an early use of pyrotechnics. It comprised sticky long-burning composition usually fired from catapults.

Green man The symbol of the Pyrotechnics Guild International depicting the

Grenade A small explosive or chemical missile designed to be thrown by hand or projected from a special launcher, usually fitted to a rifle or carbine.

Grist Particle size of pyrotechnic material. *See Granulation*.

Grommet 1) Device to protect the rotating band of projectiles. 2) An eyelet of firm material to strengthen or protect something passed through it.

Ground burst A low level burst of a shell and potentially which can be very dangerous.

Ground firework A firework designed to function at ground level.

Ground maroon A single powerful cracker designed to produce a loud report and a flash.

Ground salute *see Ground maroon*

Ground wire a conductor leading from electrical equipment to a low resistance connection with the earth.

Group a family of elements with similar chemical properties, represented by a vertical column in the periodic table.

GRP mortar Glass Reinforced Plastic - a relatively recent addition to the design of mortars. GRP mortars, usually spirally would, are light, cheap and extremely strong. However some there is some doubts as to their suitability for cylinder shells especially in larger calibres.

Guar Gum. A pale yellow powder used as a water soluble binder.

Guillotine An explosive device designed to cut by driving a hardened knife through a cable or line.

Gum Arabic (acacia gum). A tan coloured powder; a natural vegetable gum used as a water soluble binder.

Gum Copal (K.D. Gum) Light tan coloured, tropical tree resin derived powder. Used as a fuel and binder. Soluble in alcohol.

Gum Tragacanth Water and hydrogen peroxide soluble binder and adhesive.

Gums *Material to be added later*

Guncotton Nitrocellulose containing 13 percent or more of nitrogen.

Gunpowder Fireworkers prefer the term Blackpowder although chemically and physically the two are the same. Gunpowder upon combustion produces about 43% gas, 56% solids and 1% water vapour.

H

Halogen Any of the five chemical elements in group VIIa of the Periodic Table. Fluorine, Chlorine, Bromine, Iodine, and the radioactive Astatine are non-metallic, monovalent negative ions and exist in pure form as diatomic molecules. The first four elements exhibit an almost perfect gradation of physical properties. Fluorine is the least dense and chemically the most active, displacing other halogens from their compounds and oxygen from water. Iodine is the least active. The halogens form numerous compounds with each other, and with other elements, such as hydrogen halides, metal halides Salts), and halocarbons.

Hammer shell A shell, typically multi-break, comprising colour breaks and reports timed to break in alternation.

Hanabi Japanese word for Fireworks, roughly translated as "flowers of fire"

Hangfire A fuse or pyrotechnic composition that continues to burn very slowly, often almost invisibly, rather than at it's design speed. As such a hangfire presents a serious danger to firers. Also includes the detonation of an explosive charge at some non-determined time after its normally designed firing time.

Hardness a characteristic of water, imparted by salts of calcium, magnesium, and iron, such as bicarbonates, carbonates, sulphates, chlorides, and nitrates that cause curdling of soap, deposition of scale in boilers, damage in some industrial process, and sometimes objectionable taste. It may be determined by a standard laboratory procedure or computed from the amounts of calcium and magnesium as well as iron, aluminium, manganese, barium, strontium, and zinc; expressed as equivalent parts per million of calcium carbonate.

Hazard A source of danger; exposure or liability to injury or harm.

Hazardous *Material to be added later*

HC Mixture Solid non-persistent screening smoke that, when burning, produces a greyish white smoke having a sharp, acrid odour; toxic if released in sufficient quantities in enclosed places; used in bombs, shells, grenades and smoke pots. The smoke is cool burning as contrasted with white phosphorous and tends to cling to the earth.

HDPE mortar High Density Polyethylene - an extremely useful material for mortars. Belling rather than fragmentation of HDPE mortars tends to occur with failure of normal (not salute) shells.

HE High explosive (such as *dynamite*).

Heat Capacity or thermal capacity, ratio of the change in Heat energy of a unit mass of a substance to the change in Temperature of the substance. The heat capacity is a characteristic of a substance; it is often expressed in Calories per gram per degree Celsius or British Thermal Units per pound per degree Fahrenheit.

Heat Of Combustion Heat evolved in the complete oxidation of a substance under standard conditions of pressure and temperature.

Heat Of Explosion Heat evolved in burning (exploding) a sample in a combustion bomb in an inert atmosphere under standard conditions of pressure and temperature. Products of explosion vary with the oxygen balance of the sample.

Heat Of Formation Heat evolved, or absorbed, when a compound is formed by combination of its elements.

Heat Of Reaction Heat evolved when a sample is burned in an atmosphere of helium or other inert gas.

Heat Test Accelerated stability test of an explosive material.

Heat The internal Energy of a substance, associated with the positions and motions of its component molecules, atoms, and ions. The average kinetic energy of the molecules or atoms, which is due to their motions, is measured by the Temperature of the substance; the potential energy is associated with the state, or phase, of the substance (States Of Matter). Heat energy is commonly expressed in Calories, British Thermal Units (BTU), or Joules, (Work). Heat may be transferred from one substance to another by three means: Conduction, Convection, and Radiation.

Heavy metals a general term given to the ions of metallic elements such as copper, zinc, chromium, and aluminium. They are removed from wastewater by forming an insoluble precipitate (usually a metallic hydroxide).

Helium [He], gaseous element, first observed spectroscopically in the sun during a solar eclipse in 1868. Its noncombustibility and buoyancy make this extremely unreactive Inert Gas the most suitable of gases for balloons and airships. Deep-sea divers often breathe a helium-and-oxygen mixture; because helium is less soluble in human blood than nitrogen, its use reduces the risk of the bends. Liquid helium is essential for low-temperature work Cryogenics, Superconductivity. Helium is also used in arc welding and gas-discharge lasers. Abundant in outer space, helium is the end product of fusion processes in stars.

HEP Shell High-Explosive Plastic Shell.

Hermetic Seal A seal made impervious to air and fluids.

Hertz (Hz) A synonym for "cycles per second". Hertz, Heinrich Rudolf, 1857-94, German physicist. He confirmed James Clerk Maxwell's electromagnetic theory and produced and studied electromagnetic waves (radio waves), which he showed are long transverse waves that travel at the speed of light and can be reflected, refracted, and polarized like light. The unit of frequency, the hertz, is named for him. In electrical/electronic applications with alternating current, a unit of frequency where 1 Hz equals one cycle per second.

Hexachlorobenzene [C6Cl6] fine white needles which melt at 229ÝC. Used as a chlorine donor.

Hexachloroethane [C2Cl6] (carbon hexachloride). White crystalline powder, with slight camphor-like smell, very volatile at room temperature. Used as a chlorine donor in firework compositions, also in white smokes, and sometimes used as an oxidizer.

Hexamine [C6H12N4] (hexamethylenetetramine, methenamine). White powder used as an accessory fuel often in blue star comps. Burns with a yellow flame. Sometimes used in indoor firework formulae.

High Explosive (HE) Explosive which undergoes an extremely rapid chemical transformation thereby producing a high order detonation and shattering effect. High explosives are used as bursting charges for bombs, projectiles, grenades, mines and for demolition. An explosive that is capable of detonating when unconfined.

High Explosives A high explosive is characterized by the extreme rapidity with which its decomposition occurs; this action is known as detonation. When initiated by a blow or shock, it decomposes almost instantaneously, either in a manner similar to an extremely rapid combustion or with rupture and rearrangement of the molecules themselves. Explosives that are characterized by a very high rate of reaction, high pressure development, and the presence of a detonation wave in the explosive.

High Order Detonation A detonation rate equal to or greater than the stable detonation velocity of the explosive.

High-Angle Fire delivered at elevations greater than the elevation of maximum range, its range, therefore, decreasing as the angle of elevation is increased. Mortars deliver high angle fire.

Histogram A graph whose axes are the frequency of measurements and the actual measured values.

HMX Homocyclonite family; specifically cyclotetramethylenetetranitramine, the U.S name for Octogen, as an acronym for High Melting Explosive, and in the UK as Her Majesty's Explosive.

HNS Abbreviation for hexanitrostilbene, also called hexanitrodiphenylethylene. A heat resistant explosive, commonly used in deep well charges found in the oil field or in applications requiring the explosive to withstand significant temperatures before initiation. C6H2(N02)3. Molecular weight 450.24, nitrogen content 18.67%, melting point 316ÝC; detonating velocity 7000 m/s at density of 1.7 g/cc. Made in type I and type II and grades A and B. Differences between type I and type II is primarily the particle size (type I, 1-5 microns, type II, 100 - 300 microns). HNS has a uniquely small critical diameter of 0.020". It is relatively insensitive to heat, spark, impact and friction, yet it finds wide use as a heat resistant booster charge for military applications.

Hot (circuit) connected, alive, and energized.

Hot-melt glue Very popular for certain applications. A petro-chemical product applied by the use of a special gun-like dispenser. Care must be taken with many applications due to the heat when in near contact to pyrotechnic substances and the similar hazards of electricity. Big Bang Fireworks

HSE The British Health and Safety Executive - the legislative and enforcement body in the UK.

Hummer A device that produces a humming sound, usually made from a thick walled tube filled with composition, sealed at both ends, and pierced tangentially to the inner diameter. The sound is made as the device spins rapidly in flight.

Hydrocarbon A hydrocarbon is any organic compound composed solely of Carbon and Hydrogen. Hydrocarbons include aliphatic compounds, in which the carbon atoms form a chain, and Aromatic Compounds, in which the carbon atoms form stable rings. The aliphatic group is divided into alkanes (e.g. Methane and Propane), alkenes, and alkynes (e.g., Acetylene), depending on whether the molecules of the compounds contain, respectively, only single bonds, one or more carbon-carbon double bonds, or one or more carbon-carbon triple bonds. Petroleum distillation yields useful fractions that are hydrocarbon mixtures, e.g. Natural Gas, Gasoline, Kerosene, home heating oil, lubricating oils, Paraffin, and asphalt. Coal Tar is also a source of hydrocarbons. Hydrocarbon derivatives contain additional elements, e.g., oxygen, and include Alcohols, aldehydes, ketones, carboxylic acids, and halocarbons.

Hydrogen Bomb A weapon deriving a large portion of its energy from the nuclear fusion of hydrogen isotopes. In fusion, lighter elements are joined together to form heavier elements, and the end product weighs less than the components forming it. The difference in mass is converted into energy. Because extremely high temperatures are required to initiate fusion reactions, a hydrogen bomb is also known as a thermonuclear bomb. The presumable structure of a hydrogen bomb is as follows: an Atomic Bomb is surrounded by a layer of lithium deuteride (a compound of lithium and deuterium) and then by a tamper, or thick outer layer, frequently of fissionable material, that holds the contents together in order to obtain a larger explosion. The atomic explosion produces neutrons that fission the lithium into helium, tritium, and energy, and also produces the extremely high temperature needed for the subsequent fusion of deuterium with tritium, and tritium with tritium. Explosion of the neutron bomb, which has a minimal atomic trigger and a nonfissionable tamper, produces blast effects and a hail of lethal neutrons but almost no radioactive fallout. The first thermonuclear bomb was exploded in 1952 at Enewetak by the U.S., the second in 1953 by the USSR.

Hydrogen [H] is a gaseous element, discovered by Henry Cavendish in 1766. The first element on the Periodic Table, hydrogen is colorless, odorless, tasteless, slightly soluble in water, and highly explosive. The hot flame produced by a mixture of oxygen and hydrogen is used in welding, and in melting quartz and glass. Normal hydrogen is diatomic (Allotropy). The most abundant element in the universe, hydrogen is the major fuel in fusion reactions of the Sun and other Stars. Atmospheric hydrogen has three isotopes: protium (nucleus: one proton), the most common; deuterium, or heavy hydrogen (nucleus: one proton and one neutron), used in particle accelerators and as a tracer for studying chemical-reaction mechanisms; and tritium (nucleus: one proton and two neutrons), a radioactive gas used in the hydrogen bomb, in luminous paints, and as a tracer. Hydrogen's principal use is in the synthesis of Ammonia; liquid hydrogen has been greatly used as a rocket fuel, in conjunction with oxygen or fluorine. Deuterium oxide, or heavy water, is used as a moderator in nuclear reactors.

Hydrogen ion concentration the normality of a solution with respect to hydrogen ions, H+; it is related to acidity measurements in most cases by the equation pH= log 1/2[1/(H+)] where H+ is the hydrogen ion concentration in gram equivalents per litre of solution.

Hydrogenation the infusing of unsaturated or impure hydrocarbons with hydrogen gas at controlled temperatures and pressures for the purpose of obtaining saturated hydrocarbons and/or removing various impurities such as sulphur and nitrogen.

Hydrology study of water and its properties, including its distribution and movement in and through the land areas of the earth. The hydrologic cycle consists of the passage of water from the oceans into the atmosphere; onto, through, and under the lands; and back to the ocean. Hydrology is mainly concerned with the part of the cycle that follows the precipitation of water onto the land and precedes its return to the oceans.

Hydrolysis is a chemical reaction of a compound with Water, usually resulting in the formation of one or more new compounds. The most common hydrolysis occurs when a salt of a weak acid or weak base (or both) is dissolved in water. Water ionizes into negative hydroxyl ions (OH-) and positive hydrogen ions (H+), which become hydrated to form positive hydronium ions (H3O+). The salt also breaks up into positive and negative ions, and the formed ions recombine.

Hydroxide chemical compound that contains the hydroxyl (-OH) radical. The term refers especially to inorganic compounds. Organic compounds that have the hydroxyl radical as a functional group are referred to as Alcohols. Most metal hydroxides are bases. Alkali Metals hydroxides, such as sodium hydroxide (NaOH), are strong bases and are very soluble in water. The Alkaline-Earth Metal hydroxides are less basic, and magnesium

hydroxide (Milk of Magnesia) is only slightly basic. Some hydroxides, such as aluminum hydroxide {Al(OH)3}, exhibit Amphoterism.

Hydroxyethyl Cellulose. (HEC or Cellosize™). Water soluble binder; partially soluble in ethanol or acetone.

Hydroxyl radical an oxygen and hydrogen atom occurring as a group (OH-).

Hygroscopic The property of a material that causes it to absorb and retain moisture from the air. Hygroscopic compounds find only limited use in firework manufacture.

Hygroscopicity The tendency of a substance to absorb any available moisture from its surroundings; specifically the absorption of water vapour from the atmosphere.

Hypergolic A two-component propellant system, which is capable of spontaneous ignition upon contact.

Hypervelocity Muzzle velocity of an artillery projectile of 3,500 feet per second or more.

I

Ice is formed when water is cooled below its freezing point. It is a transparent crystalline solid with a relative density of 0.916, water attains its maximum density at 4ÝC.

I.E.D.'s An acronym for improvised explosive device - a term used to describe any homemade bomb or booby trap.

Igniter cord *also see Plastic Igniter Cord*, generally made for the blasting industries in several speeds. The slow cord finds use in fireworks manufacture, particularly for fitting of delay fuses. A cord filled around a wire with a thermite like-mixture for readily igniting a multiplicity of safety fuses in sequence and that burns at a uniform rate with an external flame

Igniter Device containing a ready burning composition, used to amplify the ignition of a propelling charge by a primer. Also sometimes used to amplify the initiation of a primer in the functioning of certain types of fuzes and burster charges.

Igniter Train Step-by-step arrangement of charges in pyrotechnic bombs, shells, etc., by which the initial fire from the primer is transmitted and intensified until it reaches and sets off the main charge. An explosive bomb, projectile, etc., uses a similar series, called an explosive train.

Igniting Primer designed to be initiated by flame from another primer.

Ignition Cartridge Igniter in cartridge form which may be used alone or with additional propellant increments as a propelling charge for certain pyrotechnic products.

Ignition System The system associated with rocket engines which provides for igniting the propellant.

Ignition The initiation of burning of a pyrotechnic material

Illuminant Composition A mixture of materials used in the candle of a pyrotechnic device to produce a high intensity light as its principal function. Materials used include a fuel (reducing agent), an oxidizing agent and a binder plus a color intensifier and waterproofing agent. The mixture is loaded under pressure in a container to form the illuminant charge.

Illuminating Shell Projectile with a time fuze that sets off a parachute flare at any desired height; used for lighting up an area.

Impact Fuse designed to function on impact.

Impact Sensitivity *Material to be added later*

Impedance total opposition to flow of current, measured in ohms; combined effort of resistance, inductance, and capacitance.

Implosion The opposite of explosion; an inward burst of particles, fragments, etc., due to reduced pressure.

Impulse In rocketry, product of the average thrust (in pounds or kilograms) by the burning time (in seconds).

Incendiary 1) Chemical agent used primarily for igniting combustible substances with which it is in contact by generating sufficient heat to cause ignition.

2) Filling for incendiary munitions such as shells, bombs, grenades and flame throwers. An incendiary may be a solid, liquid, or a gelled semi-plastic material that, by its intense heat and flame, can start fires and scorch combustible and non-combustible materials, as well as injure and inactivate personnel.

Incendivity The property of an igniting agent (e.g., spark, flame, or hot solid) whereby the agent can cause ignition.

Increment A package of propellant, forming part of the full propelling charge, which may be removed to reduce the velocity or range. Multisection Charge.

Indicator a compound that changes colour at a particular pH, or over a particular narrow range of pH, used to show titration end points.

Indicators Acid-Base Organic compounds that in water solution exhibit color changes indicative of the acidity or basicity of the solution (Acids & Base). Litmus, for example, is red in acidic solution and blue in basic. Other common indicators are phenolphthalein and methyl orange.

Indoor fireworks In terms of the British and European standards devices of very limited power suitable for use indoors. Types include sparklers, snakes and other novelty items.

Inert Descriptive of condition of a device that contains no explosive, pyrotechnic, active chemicals or chemical agent.

Inert Gas or noble gas, any of the elements in group 0 of the Periodic Table. In order of increasing atomic number, they are Helium, Neon, Argon, Krypton, Xenon, and Radon. Sometimes called the rare gases (although argon makes up 1% of the atmosphere), they are colourless, odourless, and tasteless. Inert gases have very low chemical activity because their outermost, or valence, electron is complete, containing two electrons in the case of helium and eight in the remaining cases.

Inertia in physics, the resistance of a body to any alteration in its state of motion, i.e., the resistance of a body at rest to being set in motion or of a body in motion to any change of speed or direction of motion.

Infrared Radiation is Electromagnetic Radiation having a wavelength in the range of 750 to 1,000,000 nanometers, thus occupying that part of the electromagnetic spectrum with a frequency less than that of red visible Light and greater than that of Microwaves. Infrared radiation is thermal, or heat, radiation, and is produced by any body having a temperature above absolute zero. It has many of the same properties as visible light, such as being reflected or refracted.

Inhibitor A material applied to the surface(s) of propellant grains to prevent burning on the coated surface(s).

Initial Velocity The starting highest velocity, referred to as V1. *See Muzzle Velocity*.

Initiating Explosive *Material to be added later*

Initiation As applied to an explosive item, the beginning of the deflagration or detonation of the explosive; the first action in the first element of an explosive train. The act of causing an explosive material to detonate or deflagrate.

Initiation Explosives The initiation of an explosive reaction requires the application of energy in some form. Propellants are commonly ignited by the application of flame, while disrupting explosives are set off by a severe shock. The device used to initiate the burning of a propellant is called a primer. The device used to initiate the reaction of a disrupting explosive is called a detonator.

Initiator A detonator or detonating cord used to start detonation in an explosive material. Or a small quantity of very sensitive/powerful explosive, or detonator, used to start the detonation of another less sensitive explosive. Mercury fulminate, lead azide and tetryl are the principal high explosives used as initiators.

Instantaneous Detonator A detonator that has a firing time of essentially 0 sec as opposed to delay detonators which have firing times of from several milliseconds to several seconds.

Institute of Makers of Explosives (IME) A non-profit safety-oriented trade association representing leading producers of commercial explosive materials in the United States and Canada and dedicated to safety in the manufacture, transportation, storage, handling, and use of explosive materials.

Insulation A material used to inhibit or prevent the Conduction of heat or of electricity. Common heat insulators are asbestos, cellulose fibres, feathers, fibreglass, fur, stone, wood, and wool; all are poor conductors of heat. In the conduction of electricity from point to point, the conductor acts as a guide for the electric current and must be insulated at every point of contact with its support to prevent escape, or leakage, of the current. Good electrical insulators, or Dielectrics, include dry air, dry cotton, glass, paraffin, porcelain, resin, rubber, and varnishes.

Integrated Circuit Electric Circuit or module packaged as a single unit with leads extending from it for input, output, and power-supply connections. All the electronic devices are formed by selective treatment (doping) of a single chip of Semiconductor material. Integrated circuits are categorized according to the number of Transistors or other active circuit devices they contain; an active circuit device is one that receives power from a source other than its input signal. An ordinary integrated circuit (IC) may contain up to several tens of such devices; a medium-scale integrated circuit (MSI), many tens to several hundred; a large-scale integrated circuit (LSI), several hundred to a few thousand; and an extra-large integrated circuit (ELSI), a few thousand or more.

Interface A common boundary between one component and another.

Interference in physics, the effect obtained when two systems of Waves reinforce, neutralize, or in other ways interfere with each other. Interference is observed in waves both in a material medium (such as Sound) and in Electromagnetic Radiation. Constructive interference occurs when two waves in the same phase combine. The waves reinforce each other, and the amplitude of the resulting wave is equal to the sum of the amplitudes of the interfering waves. When the phases of the two waves are shifted over 180Ý, i.e., the maximum positive amplitude of one wave coincides with the maximum negative amplitude of the other wave, destructive interference occurs, which results in the cancelling of the waves when they have the same amplitude.

Interior Ballistics Subdivision of the study of ballistics which deals with that part of the phenomena within the chamber and bore of a weapon associated with imparting kinetic energy to missiles.

Inventory A listing of all explosive materials stored in a magazine.

Iodine *Material to be added later*

Ion An ion is an atom, or group of atoms, having a net electric charge, acquired by gaining or losing one or more electrons or protons. A simple ion consists of only one charged atom; a complex ion consists of an aggregate of atoms with a net charge. Because the electron and proton have equal but opposite unit charges, the charge of an ion is always expressed as a whole number of positive or negative unit charges. If an atom or group loses electrons or gains protons, it will have a net positive charge and is called a cation. If an atom or group gains electrons or loses protons, it will have a net negative charge and is called an anion.

Ion exchange a chemical reaction in which mobile hydrated ions of a solid are exchanged, equivalent for equivalent, for ions of like charge in solution.

Ionic bond A type of chemical bond characterised by transfer of electrons from one atom to another. Thus common salt is written Na+Cl-. Most oxidants and colouring agents for firework compositions are ionic compounds.

Ionization a process by which a neutral atom or molecule loses or gains electrons, thereby acquiring a net charge and becoming an ion; occurs as the result of the dissociation of the atoms of a molecule in solution or of a gas in an electric field.

IR Infrared; heat radiation of longer wave length than visible light. Used for tracking, spotting and simulation.

Iron Filings [Fe + C] High carbon impurities add to the beautiful, branching, golden sparks produced in numerous compositions. Often coated to reduce the high tendancy to rust.

Iron Flake [Fe] Makes an intensely orange spray on non-branching sparks. Good for comets, stars and other effects.

Iron(II) Oxide, black (ferrous oxide, triiron tetraoxide). **[FeO or Fe3O4]** A black powder which can be used in ignition compositions and first fires.

Iron(III) Oxide, red (ferric oxide). **[Fe2O3]** Red powder used in some glitter formulations; as a catalyst in rocket

Isobaric Flame Temperature The temperature of a propellant flame under constant pressure conditions.

Isochoric Flame Temperature The temperature of a propellant flame under constant volume conditions.

Isomer in chemistry, one of two or more compounds having the same molecular formula (i.e., the same number of atoms of each element in a molecule) but different structures (arrangements of atoms in the molecule). Isomers have the same number of atoms of each element in them and the same atomic weight but differ in other properties. Structural isomers, e.g., Ethanol (CH3CH2OH) and dimethyl ether (CH3OCH3), differ in the way the atoms are joined together in their molecules. Stereoisomers have the same basic arrangement of atoms in their molecules but differ in the way the atoms are arranged in space. Geometric isomers, which are stereoisomers that differ in the positioning of groups about a double bond or some other feature that gives the molecule a certain amount of structural rigidity, differ in physical properties such as melting and boiling points. Optical isomers are stereoisomers in which the two molecules are mirror images of each other and, each being asymmetrical, cannot be superposed on each other; optical isomers differ in the direction in which they rotate light passed through the molecules.

Isotope An isotope is one of two or more atoms having the same Atomic Number but differing in Atomic Weight and Mass Number. The nuclei of isotopes of the same element have the same number of Protons (equal to the element's atomic number) but have different numbers of Neutrons. The isotopes of a given element have identical chemical properties but slightly different physical properties. A radioactive isotope, or radioisotope, is a natural or artificially created isotope having an unstable nucleus that decays emitting alpha, beta, or gamma rays (Radioactivity) until stability is reached. For most elements, stable and radioactive, isotopes are known.

J

Japanese style shell The ultimate spherical burst shell. The Japanese strive to produce perfect symmetry and patters in their shells. Japanese shells are also noted for the contrasting coloured pistils that form part of the burst of many effects.

JATO (Jet Assisted Take-Off) A rocket motor used to assist the take-off of an aircraft.

Jell Something gelatinised (like "jelly"), like "jellied gasoline" (gasoline thickened with "Napalm.")

Jet The central stream of high velocity particles or gases from a shaped charge.

Jigs A tool used in the filling of fireworks or for performing some other operation on a unfinished firework.

Jolt And Jumble Tests intended to simulate the shocks various components of ammunition are subjected to in transportation and handling.

Joule Symbol J. 1 Joule = 1 Newton-meter = 0.738 ft/lb.

Jump The movement which the tube of the gun describes under the shock of firing, but before the projectile leaves the muzzle. Usually expressed as an angle.

K

K Temperature degree Kelvin or absolute on the centigrade scale; degrees C equals degree centigrade; sometimes also used: degrees R equals Rankine, in the absolute Fahrenheit scale.

Kamuro A long burning stars, usually silver or gold, that fall a substantial distance from the centre of the shell burst, which sometimes changing colour towards the end of their flight.

Kcal Kilogram calorie equals 1000 cal.

Kepler's Laws three mathematical statements by Johannes Kepler that accurately describe the revolutions of the planets around the sun. The first law states that the shape of each planet's orbit is an ellipse (Conic Section) with the sun at one focus. The second law states that if an imaginary line is drawn from the sun to the planet, the line will sweep out equal areas in space in equal periods of time for all points in the orbit. The third law states that the ratio of the cube of the semimajor axis of the ellipse (i.e., the average distance of the planet from the sun) to the square of the planet's period (the time it needs to complete one revolution around the sun) is the same for all the planets. Newton gave a physical explanation of Kepler's laws with his laws of Motion and law of Gravitation.

Kerosene or kerosine, American name for liquid paraffin, a colourless, thin oil that is less dense than water. It is a mixture of Hydrocarbons commonly obtained in the fractional Distillation of Petroleum, but also from coal, oil shale, and wood. Once the most important refinery product because of its use in lamps, now used chiefly as a fuel in jet engines.

Kg Kilogram equals 1000 grams

Kinetic Energy Ammunition whose effectiveness is dependent upon its high density (mass) and high velocity.

Kinetic-Molecular Theory of Gases , physical theory that explains the behaviour of gases by assuming that any gas is composed of a very large number of very tiny particles, called molecules, that are very far apart compared to their sizes. The molecules are assumed to exert no forces on one another, except during rare, perfectly elastic collisions. A gas corresponding to these assumptions is called an ideal gas. The analysis of the behaviour of an ideal gas according to the laws of mechanics leads to the Gas Laws. The theory also shows that the absolute Temperature is directly proportional to the average kinetic energy of the molecules. Pressure is seen to be the result of large numbers of collisions between molecules and the walls of the container in which the gas is held.

Kraft paper A strong paper used for pasting shells and for capping.

Krypton [Kr], gaseous element, discovered by William Ramsay and M.W. Travers in 1898. It is a rare Inert Gas used to fill electric lamp bulbs and various electronic devices, and to detect heart defects. The definition of a meter is based on the emission spectrum of the krypton-86 isotope.

L

Lactose [C12H22O11.2H2O] A white powder used in smoke formulations and as a low reactivity (accessory) fuel. Sometimes used in Blue firework compositions.

Laminac A (proprietary) plastic binder material, the general class term is "unsaturated polyester."

Lampblack [C] An extremely lightweight black powder used in fireworks to produce very long lasting, finely dispersed gold sparks in stars. Very "dirty" to work with.

Lance Usually a small, thin walled, tube containing coloured composition used to make lancework.

Lancework Usually a message, logo, or design made on a wooden lattice work frame comprising many lances fused together

Lands Raised portion between grooves in the bore of a rifled gun.

Lanthanide Series Rare - Earth Metals with atomic numbers 58 through 71 in group IIIb of the Periodic Table. They are, in order of increasing atomic number, Cerium, Praseodymium, Neodymium, Promethium, Samarium, Europium, Gadolinium, Terbium, Dysprosium, Holmium, Erbium, Thulium, Ytterbium, and Lutetium. Although they closely resemble Lanthanum and each other in their chemical and physical properties, lanthanum (at. no. 57) is not always considered a member of the series.

Lanyard A cord, wire, etc. for firing certain fuses.

LASER An acronym for Light Amplification By Stimulated Emission Of Radiation. Laser is made up of light waves that are nearly parallel to each other, all traveling in the same direction. Lasers emit beams of coherent light of a single colour or wave length and frequency.

Lateral Deviation Horizontal distance between the point of impact or burst and the gun-target line.

Lead Azide Very sensitive high explosive used in small quantities to initiate other less sensitive high explosives. This agent has largely replaced mercury fulminate in military ammunition.

Lead Dioxide [PbO2] fine brown coloured powder similar uses to lead oxide.

Lead Oxide [Pb3O4] fine red powder. Used in ignition and first fire compositions, limited use in fireworks.

Lead Tetraoxide. (lead oxide, red lead, minimum). **[Pb3O4]** A red-orange coloured powder commonly used to make crackling microstars ("Dragon Eggs"); occasionally in hot burning primes.

Leader The initial fuse of a firework shell that transfers fire from the delay fuse (if any) to the lifting charge of the shell. For small calibre shells the leader may be used to lower the shell to the bottom of the mortar tube, but this is not good practise with larger calibre shells.

Leading (Lead) Lines or Wires The wire(s) connecting the electrical power source with the circuit containing electric detonators (Firing Line).

Leading Wire An insulated wire used between the electric power source and the electric igniters or detonator circuit.

Leaflet Shell Usually consists of standard-base ejection smoke shell, of any calibre, with smoke canisters removed and propaganda substituted therefore.

Leakage Resistance The resistance between the blasting circuit (including lead wires) and the ground.

LEDC Low energy detonating cord commercial version of mild (miniature) detonating fuse.

Legwires The two single wires or one duplex wire extending out from an electric detonator, which are permanently attached to the electric detonator.

Lens A device for forming an image of an object by the refraction, or bending, of light. In its simplest form it is a disk of transparent substance, commonly glass, with its two surfaces curved or with one surface plane and the other curved. Generally each curved surface-called convex if curved outward and concave if curved inward-of a lens is made as a portion of a spherical surface; the centre of the sphere is called the centre of curvature of the surface. All rays of light passing through a lens are refracted except those that pass directly through a point called the optical centre. A divergent lens (thicker at the edges than at the centre) bends parallel light rays passing through it away from each other. The image formed by a diverging lens is always erect (upright), smaller than the object, and virtual (located on the same side of the lens as the object). A convergent lens (thicker at the centre than at the edges) bends parallel light rays toward one another; if they are parallel to the principal axis of the lens, they converge to a common point, or focus (F), behind the lens. The image formed by a converging lens depends on the position of the object relative to the lens's focal length (distance between the focus and the optical centre) and its centre of curvature.

Lifting charge The charge beneath an aerial shell (or Roman candle unit) which propels the unit into the air. The lifting charge almost universally used in firework manufacture is granulated blackpowder.

Lifting Plug Threaded eyebolt which fits into the fuze cavity, permitting heavy shells to be handled by means of a winch.

Light That part of Electromagnetic Radiation to which the human eye is sensitive. The wavelengths of visible light range from c.400 to c.750 nanometers. If white light, which contains all wavelengths, is separated into a Spectrum, each wavelength is seen to correspond to a different Colour. The scientific study of the behaviour of light is called Optics; it covers Reflection of light by a Mirror or other object, Refraction of light by a Lens or Prism, and Diffraction of light as it passes by an opaque object. Christiaan Huygens proposed (1690) a theory that explained light as a Wave phenomenon. Isaac Newton, however, held (1704) that light is composed of tiny particles, or corpuscles, emitted by luminous bodies. By combining his corpuscular theory with his laws of mechanics, he was able to explain many optical phenomena. Newton's corpuscular theory of light was favoured over the wave theory, until important experiments, which could be interpreted only in terms of the wave theory, were done on the diffraction and Interference of light by Thomas Young (1801) and A.J. Fresnel (1814-15). In the 19th century the wave theory became the dominant theory of the nature of light. The electromagnetic theory of James Clerk Maxwell (1864) supported the view that visible light is a form of Electromagnetic Radiation. With the acceptance of the electromagnetic theory of light, only two general problems remained. It was assumed that a massless medium, the Ether, was the carrier of light waves, just as air or water carries sound

waves. The famous experiments (1881-87) by A.A. Michelson and E.W. Morley, in which they tried unsuccessfully to measure the velocity of the earth with respect to this medium, failed to support the ether hypothesis. With his special theory of Relativity, Albert Einstein showed (1905) that the ether was unnecessary to the electromagnetic theory. Also in 1905, Einstein, in order to explain the Photoelectric Effect, suggested that light, as well as other forms of electromagnetic radiation, travel as tiny bundles of energy, called light quanta, or Photons, that behave as particles (Quantum Theory). Light thus behaves as a wave, as in diffraction and interference phenomena, or as a stream of particles, as in the photoelectric effect. The theory of relativity predicts that the speed of light in a vacuum (186,282 mi/sec = 299,792.458 km/sec) is the limiting velocity for material particles.

Lightning, electrical discharge accompanied by Thunder, commonly occurring during a Thunderstorm. The discharge may take place between two parts of the same cloud, between two clouds, or between a cloud and the earth. Lightning may appear as a jagged streak (forked lightning), as a vast flash in the sky (sheet lightning), or, rarely, as a brilliant ball (ball lightning). The electrical nature of lightning was proved by Benjamin Franklin in his famous kite experiment of 1752.

Light-Year, in astronomy, the distance (5.87 + 1012 mi/9.46 + 1012 km) that Light travels in one sidereal year.

Lignite, or brown coal, carbon-containing fuel intermediate between Coal and Peat, brown or yellowish in colour and woody in texture. Lignite contains more moisture than coal and tends to dry and crumble when exposed to air. It burns with a long, smoky flame but little heat.

Lime any of a family of chemicals consisting essentially of calcium hydroxide made from limestone (calcite), which is composed mostly of calcium carbonate or a mixture of calcium carbonate and magnesium carbonate.

Limit In mathematics, a value approached by a sequence or a function under certain specified conditions. For example, the terms of the sequence +, +, 1/8, 1/16, … are obviously getting smaller and smaller. Because one can, if enough terms are taken, make the last term as small, i.e., as close to zero, as one pleases, the limit of this sequence is said to be zero. If sn denotes the nth term of a sequence, the equation sn = s (read "the limit of sn as n approaches infinity is s") expresses the fact that s is the limit of the sequence; in the example, sn = 1/2n and 1/2n = 0. Similarly, although the function f(x) = (x - 1)/(x2 - 1) is not defined for x = 1 (where the denominator would be zero), values of x increasingly close to 1 yield values of f(x) increasingly close to +. Thus, the limit of f(x) as x approaches 1 is +, which is symbolized as f(x) = +. Limits are the basis of differential and integral Calculus.

Line rocket A rocket designed to travel along a wire or rope.

Linear Burning Rate The rate of regression of a burning propellant surface, measured normal to the surface. Piobert's Law.

Liner

1) Inner tube, in a cannon, which bears the rifling and which may be replaced when worn out.

2) Cone of material used as an integral part of shaped charges.

3) A material applied to the inside of a solid rocket case which adheres to both the case and the propellant.

Linseed Oil *Material to be added later*

Liquid Fuels in a liquid state. They may be used with oxidizers to form explosive materials.

Litharge. (lead monoxide, lead oxide, plumbous oxide). **[PbO]**. Fine brown powder used in (friction) match-head compositions and smoke formulations.

Lithium Carbonate [Li2CO3] white crystalline powder, the red flame colouration finds limited use in indoor fireworks.

Lithium [Li] metallic element, discovered in 1817 by J.A. Arfvedson. A soft, silver-white corrosive Alkali Metal, lithium is the least dense metal. Lithium compounds are used in lubricating greases, special glasses, and ceramic glazes; as brazing and welding fluxes; and in the preparation of plastics and synthetic rubber. Lithium is also a medical antidepressant.

Lithographic Varnish *Material to be added later*

Litmus organic dye usually used as an indicator of acidity or alkalinity (Acids and Bases). Naturally pink in colour, it turns blue in alkaline solutions and red in acids. Litmus paper is paper treated with the dye.

Live Ammunition containing explosives. This is in contrast to drill ammunition (dummy ammunition), which contains no explosives and is used in training.

Loading Density The weight of explosive loaded per unit length of borehole occupied by the explosive, expressed as pounds per foot or kilograms per metro of borehole.

Loading Placing explosive material in a mortar or against any material to be blasted.

Loading Ratio The weight of explosive loaded per unit length into a device to accomplish a breach of a specific area. Total area breached divided by the total charge weight.

Logarithm The power to which a number, called the base, must be raised in order to obtain a given positive number. For example, the logarithm of 100 to the base 10 is 2, because 102 = 100. Common logarithms use 10 as the base; natural, or Napierian, logarithms (for John Napier) use the number e as the base.

Logic Circuit An Electric Circuit whose output depends upon the input in a way that can be expressed as a function in symbolic Logic; it has one or more binary inputs (capable of assuming either of two states, e.g., "on" or "off") and a single binary output. Logic circuits that perform particular functions are called gates. Basic logic circuits include the AND gate, the OR gate, and the NOT gate, which perform the logical functions AND, OR, and NOT. Logic circuits, which are mainly used in digital Computers, can be built from any binary electric or electronic devices, including Switches, Relays, Electron Tubes, solid-state Diodes, and Transistors.

Logic The systematic study of valid inference. Classical, or Aristotelian, logic is concerned with the formal properties of an argument, not its factual accuracy. Aristotle, in his Organon, held that any logical argument could be reduced to a sequence of 3 propositions (2 premises and a conclusion), known as a Syllogism, and posited 3 laws as basic to all logical thought: the law of identity (A is A); the law of contradiction (A cannot be both A and not A); and the law of the excluded middle (A must be either A or not A).

Lot Number Code number that identifies a particular quantity of ammunition from one

manufacturer. The number is assigned to each lot of ammunition when it is manufactured.

Loudspeaker or speaker, a device used to convert electrical energy into sound. It consists essentially of a thin flexible sheet called a diaphragm that is made to vibrate by an electric signal from an Amplifier. The vibrations create sound waves in the air around the speaker. In a common dynamic speaker, the diaphragm has a cone shape and is attached to a wire coil suspended in a magnetic field. A signal current in the suspended coil creates another magnetic field that interacts with the already existing field, causing the coil and the diaphragm attached to it to vibrate. Quality sound systems employ three different sized speakers. The largest one, the woofer, reproduces low frequencies; the medium-sized one, called a mid-range speaker, reproduces middle frequencies; the smallest one, called a tweeter, reproduces high frequencies.

Low Explosives that are characterized by deflagration or a low rate of reaction and the development of low pressure. Explosive which undergoes a relatively slow chemical transformation, thereby producing a deflagration or an explosion, the effect ranging from that of a rapid combustion to that of a low order detonation. It is suitable for use in Ignitor trains and certain types of propellants. Low explosives are mostly solid combustible materials that decompose rapidly, but do not normally explode. This action is known as deflagration. Low explosives do not usually propagate a detonation. Under certain conditions, however they react in the same manner as high explosives and they may detonate.

Lower Acceptable Mean Maximum Pressure For any type gun, that value of the maximum pressure noted in the propellant specification as the lower limit for the average maximum pressure developed by an acceptable smokeless propellant, in the form of propelling charges, which will impart the specified muzzle velocity to the specified projectile. Smokeless propellant is considered as having failed to pass the test if, in acceptance tests, it develops an average maximum pressure lower than this value.

LSC (Linear Shaped Charge) Less flexible, or rigid, version of FLSC.

Lupersol A trade name for a catalyst for polyesters.

M

M.O.E. Method Of Entry

M-80 A type of small, but powerful, device containing flash powder. M-80s are now banned from sale in the US.

Mach Number Ratio of the velocity of a body to that of Sound in the same medium. A plane travelling at Mach 2.0 is travelling at twice the speed of sound.

Mach Wave Supersonic shock wave.

Machine A construction, commonly used in the 19th and early 20th Centuries, to "enhance" the spectacle of f fireworks display. Great efforts were made to disguise the presence of fireworks within statues and ornaments, which would then be ignited to produce the intended, but concealed, firework effect.

Magazine Any building or structure or container other than an explosives manufacturing building approved for the storage of explosive materials.

Magnalium The most commonly used alloy in firework making. Magnalium is usually a 1:1 mixture of magnesium and aluminium and is described chemically as a eutectic mixture of Al2Mg3 in Mg2Al3.

Magnesium Carbonate [MgCO3] White powder used as a glitter delay agent; sometimes as a free-flow agent for some potassium chlorate and perchlorate mixes. It is also used in smoke compositions with @ 2 to 3% the weight of the oxidizer also has use as a neutraliser.

Magnesium [Mg] is a metallic element, discovered as an oxide by Sir Humphrey Davy in 1808. A ductile, silver-white, chemically active Alkaline-Earth Metal, it is the eighth most abundant element in the earth’s crust. Its commercial uses include lightweight alloys in aircraft fuselages, jet-engine parts, rockets and missiles, cameras, and optical instruments. The metal is used in pyrotechnics. Magnesium is found in plant chlorophyll and is necessary in the diet of animals and humans.

Magnesium Oxide [MgO] White powder.

Magnesium-Aluminium, granular powder, Mg/Al 50:50 alloy used in fountains to produce silver sparks with a crackling sound.

Magnetic Resonance in physics and chemistry refers to the phenomenon produced by simultaneously applying a steady magnetic field and Electromagnetic Radiation (usually radio waves) to a sample of atoms and then adjusting the frequency of the radiation and the strength of the magnetic field to produce absorption of the radiation. The resonance refers to the enhancement of the absorption that occurs when the correct combination of field and frequency is reached. Most magnetic resonance phenomena depend on the fact that both the proton and the electron behave like microscopic magnets-a property that can be ascribed to an intrinsic rotation, or spin. Types of magnetic resonance include electron paramagnetic resonance (EPR), involving the magnetic effect of electrons, and nuclear magnetic resonance (NMR), involving the magnetic effects of protons and neutrons in the nuclei of atoms. The NMR resonant frequency provides information about the molecular material in which the nuclei reside, and NMR is used in chemistry and physics to analyse samples of solids and liquids, as well as in medicine to analyse tissues removed from the body. Magnetic resonance imaging (MRI) is a non-invasive diagnostic technique that uses NMR to detect and analyse changes in body structure and function.

The patient is placed in the field of an electromagnet, which causes the nuclei of certain atoms in the body (especially those of hydrogen) to align magnetically. The patient is then subjected to radio waves, which cause the aligned nuclei to "flip"; when the radio waves are withdrawn the nuclei return to their original positions, emitting radio waves that are then detected by a receiver and analysed by computer. Unhampered by bone and capable of producing images in a variety of planes, MRI is used in the diagnosis of brain tumours and disorders, spinal disorders, multiple sclerosis, and cardiovascular disease. The procedure is considered to be without risk to the patient.

Magnetism *Material to be added later*

Magnitude In astronomy magnitude is a measure of the brightness of a celestial object. Apparent magnitude is that determined on the basis of an object's relative brightness as seen from the earth. Objects differing by one magnitude differ in brightness by a factor of 2.512 (the 5th root of 100). The brightest stars have a magnitude of about +1; the sun's magnitude is -26.8. Absolute magnitude, a measure of the intrinsic luminosity, or true brightness, of an object, is the apparent magnitude an object would have if located at a standard distance of 10 Parsecs.

Magnus Force 1) Force normal to the plane of yaw caused by the spin. 2) Force arising from interaction of a spinning body and the wind stream when the body is yawing. Magnus Force - Centre Of Vanishing point of Magnus moment.

Main Explosive Charge The explosive material that performs the major work of blasting.

Manganese Dioxide [MnO2] A black powder used as a catalyst to aid in decomposition of oxidizers. Increases the sensitivity of compositions containing chlorates and perchlorates by lowering the amount of energy required to ignite them.

Manganese [Mn] Dark grey powder used as a fuel to control or delay burning rates.

Manhattan Project was the wartime effort to design and build the first nuclear weapons Atomic Bomb). A $2-billion effort, centred at Oak Ridge, Tennessee, and Hanford, Wash., was required to obtain sufficient amounts of the two necessary isotopes, uranium-235 and plutonium-239. The design and building of the bombs took place at Los Alamos, New Mexico, where J. Robert Oppenheimer directed a large group of American and European-refugee scientists. Following the test explosion of a plutonium device on July 16, 1945, near Alamogordo, New Mexico, a uranium bomb and a plutonium bomb were dropped on, respectively, Hiroshima (Aug. 6) and Nagasaki (Aug. 9).

Mannitol [C9H18O] A white crystalline powder, used in delays. Also known as 3,4-0-Isopropylindene-D-Mannitol; 3,4-Monoacetone-D-Mannitol. Molecular weight 222.33: Melting Point 84ÝC-86ÝC

Manufacture The process of making fireworks from the raw materials. The term is more generally applied to any manipulation of firework components (e.g fusing shells).

Manufacturing Codes Code markings stamped on explosive materials packages, indicating, among other information, the date of manufacture.

Maroon An exploding device that produces a loud bang. Aerial maroons are the most common, the composition being wither blackpowder or flashpowder. From French - marron - chestnut (from the noise they make in a fire)

MASER An acronym for (microwave amplification by stimulated emission of radiation), device, first operated in 1954, for the creation and amplification of high-frequency radio

waves. The waves produced by the maser are coherent, i.e., all of the same frequency, direction, and phase relationship. Used as an oscillator, the maser provides a very sharp, constant signal and thus serves as a time standard for atomic clocks. The maser can also serve as a relatively noise-free amplifier. The optical maser is now called a Laser.

Mass Detonate (Mass Explode) Explosive materials mass detonate (mass explode) when a unit or any part of a larger quantity of explosive material explodes and causes all or a substantial part of the remaining material to detonate or explode simultaneously. With respect to detonators, "a substantial part" means 90% or more.

Mass Detonation (Mass Explosion) - The virtually instantaneous explosion of a mass of explosives when only a small portion is subjected to fire, severe concussion or impact, the impulse of an initiating agent, or to the effect of a considerable discharge of energy from without.

Mass Explosion Risk *Material to be added later*

Mass in physics is the quantity of matter in a body regardless of its volume or of any forces acting on it. There are two ways of referring to mass, depending on the laws of physics defining it. The gravitational mass of a body may be determined by comparing the body on a beam balance with a set of standard masses; in this way the gravitational factor is eliminated (Gravitation; Weight). The inertial mass of a body is a measure of the body's resistance to acceleration by some external force. All evidence seems to indicate that the gravitational and inertial masses are equal. According to the special theory of Relativity, mass increases with speed according to the formula m = m0/+1-v2/c2, where m0 is the rest mass (mass at zero velocity) of the body, v its speed, and c the speed of light in vacuum. The theory also leads to the Einstein mass-energy relation E = mc2, where E is the energy and m the relativistic mass.

Mass Number is represented by the symbol A, the total number of nucleons (Neutons and Protons) in the nucleus of an Atom. All atoms of a chemical Element have the same Atomic Number but may have different mass numbers (from having different numbers of neutrons in the nucleus). Atoms of an element with the same mass number make up an Isotope of the element. Isotopes of different elements may have the same mass number but different numbers of protons.

Mass Ratio The ratio of the initial mass of the propellant to the mass of the complete rocket motor.

Match The generic term for quickmatch, black match etc

Matter is anything that has mass. Because of its mass, all matter has Weight, if it is in a gravitational field, and Inertia. The three common States Of Matter are solid, liquid, and gas; scientists also recognize a fourth, Plasma. Ordinary matter consists of Atoms and Molecules.

Maximum Pressure The maximum value of the pressure exerted by the propellant gases on the walls of a gun during the firing of the round.

Maximum Recommended Firing Current The highest recommended electric current to ensure safe and effective performance of an electric detonator.

Maximum Sky Brightness Worst possible sky condition for observing pyrotechnic signals; usually uniform clouds or overcast.

Mbar Mega bar = 1,000,000 Bars

Meal powder Finely divided blackpowder available in several grades. Meal A is commonly used in fireworks.

Mean or **Average Mean** Unless otherwise specified, this is the arithmetic mean of the observations. A measure, of the variability, or dispersion of a number of observations.

Mechanical Entry The utilization of mechanical equipment such as hooligan tools, glass cutters, saws, rams, pressurized jaws, etc., to facilitate entry through a conventional or non-conventional breach point.

Mechanics is a branch of physics concerned with Motion and the Forces causing it. The field includes the study of the mechanical properties of matter, such as Density, Elasticity Strength Of Materials), and Viscosity. Mechanics is divided into Statics, which deals with bodies at rest or in equilibrium, and Dynamics, which deals with bodies in motion. Isaac Newton, who derived three laws of motion and the law of universal Gravitation, was the founder of modern mechanics. For bodies moving at speeds close to that of light, Newtonian mechanics is superseded by the theory of Relativity, and for the study of very small objects, such as Elementary Particles, Quantum Theory is used.

Median The halfway point in the measurements when they have been arranged in order of size.

Melt Loading Process of loading an explosive device by melting the explosive and allowing it to solidify in the device.

Melting Point temperature at which a substance changes its state from solid to liquid (see States Of Matter). Under standard atmospheric pressure, different pure crystalline solids will each melt at a different specific temperature; thus melting point is a characteristic of a substance and can be used to identify it. The quantity of heat necessary to change 1 gram of any substance from solid to liquid at its melting point is known as its latent heat of fusion.

Meniscus the curved upper surface of a non-turbulent liquid in a container; it is concave (curves upward) if it wets the container walls, and convex (curves downward) if it does not. For accurate measurements, readings should be taken at the flat centre of the meniscus.

Mercurous Chloride [Hg2Cl2] also known as calomel, a fine white powder. Used in the past as a chlorine donor in fireworks, although nowadays it is far too expensive.

Mercury Fulminate Sensitive explosive that is detonated by friction, impact or heat. Its military uses have been taken over to a large extent by lead azide because of the poor stability of mercury fulminate at elevated temperatures.

Mesh size The designation of the number of wires of standard thickness per inch used to make a sieve. For instance a 60 mesh sieve has a screen size of 250 microns.

Metal A chemical Element displaying certain properties, notably metallic lustre, the capacity to lose electrons and form a positive Ion, and the ability to conduct heat and electricity (Conduction), by which it is normally distinguished from a non-metal. The metals comprise about two thirds of the known elements. Some elements, e.g., arsenic and antimony, exhibit both metallic and non-metallic properties, and are called metalloids. Metals fall into groups in the Periodic Table determined by similar arrangements of the orbital electrons and a consequent similarity in chemical properties. Such groups include the Alkali Metals (Group la in the periodic table), the Alkaline - Earth Metals (Group IIa), and the Rare - Earth Metals (Lanthanide and Actinide series). Most metals other than the alkali metals and the alkaline-earth metals are called transition

metals (Transition Elements). The oxidation states, or Valence, of the metal ions vary from +1 for the alkali metals to +7 for some transition metals. Chemically, the metals differ from the non-metals in that they form positive ions and basic oxides and hydroxides. Upon exposure to moist air, a great many metals undergo corrosion, i.e., enter into a chemical reaction, the oxygen of the atmosphere uniting with the metal to form the oxide of the metal, e.g., rust on exposed iron.

Metal Fouling Deposit of metal in the bore of a gun, from the jackets or rotating bands of projectiles.

Metal salt The combination of an electropositive metal ion with an electronegative anion. For instance Potassium Nitrate.

Metallised explosives are sensitised or boostered, with metal powders or granules (usually aluminium or ferrosilicon), to yield more energy.

Methane [CH4] is a colourless, odourless, gaseous Hydrocarbon formed by the decay of plant and animal matter. It occurs naturally as the chief component of Natural Gas, as the firedamp of coal mines, and as the marsh gas released in swamps and marshes. Methane can also be made synthetically by various means. It is combustible and can form explosive mixtures with air. Used for fuel in the form of natural gas, methane is also an important starting material for making solvents and certain Freons.

Methanol or methyl alcohol or wood alcohol **[CH3OH],** a colourless, flammable liquid and the simplest Alcohol. Methanol is a fatal poison. Small internal doses, prolonged exposure of the skin to the liquid, or continued inhalation of the vapour may cause blindness. It can be obtained from wood, but now is made synthetically from the direct combination of hydrogen and carbon monoxide gases. Methanol is used to make Formaldehyde, as a solvent, and as an Antifreeze.
Methylene Chloride (dichloromethane**) [CH2Cl2]** Clear liquid solvent for PVC; used in solvent bonding of plastic shell halves

Metric System The metric system is a system of weights and measures planned in France and adopted there in 1799. Now used by most of the technologically developed countries of the world, it is based on a unit of length called the meter (m) and a unit of mass called the kilogram (kg). The meter is now defined in terms of a reproducible, universally available atomic standard, being equal to 1,650,763.73 wavelengths of the red-orange light given off by the krypton-86 isotope under certain conditions. The kilogram is defined as the mass of the International Prototype Kilogram, a platinum-iridium cylinder kept at SFvres, France, near Paris. Other metric units can be defined in terms of the meter and the kilogram. Fractions and multiples of the metric units are related to each other by powers of 10, allowing conversion from one unit to a multiple of it simply by shifting a decimal point. This avoids the lengthy arithmetical operations required by the English Units Of Measurement. The prefixes in the accompanying table have been accepted for designating multiples and fractions of the meter, the gram (= 1/1000 kilogram), and other units. Several other systems of units based on the metric system have been in wide use. The cgs system uses the centimeter (= 1/100 meter) of length, the gram of mass, and the Second of time as its fundamental units; other cgs units are the dyne of Force and the erg of Work or energy. The mks system uses the meter of length, the kilogram of mass, and the second of time as its fundamental units; other mks units include the newton of force, the joule of work or energy, and the watt of Power. The units of the mks system are generally much larger and of a more practical size than the comparable units of the cgs system. Electric and Magnetism have been defined for both these systems. The International System of Units (officially called the SystFme International d'UnitTs, or SI) is a system of units adopted by the 11th General Conference on Weights and Measures (1960). Its basic units of length, mass, and time are those of the mks system; other basic units are the Ampere of electric current, the

kelvin of temperature (a degree of temperature measured on the Kelvin Temperature scale), the candela (Photometry) of luminous intensity, and the Mole, used to measure the amount of a substance present. All other units are derived from these basic units.

Micro a prefix meaning one-millionth of a unit.

Microelectronics The branch of Electronics devoted to the design and development of extremely small electronic devices that consume very little electric power. The simplest, but least effective, approach used is to make circuit elements, such as resistors (Resistance), Capacitors, and Semiconductor devices, extremely small but discrete. In another approach, circuit elements fabricated as thin films of conductive, semi-conductive, and insulating materials are deposited in sandwich form on an insulating substrate. The most advanced method is to form circuits, called Integrated Circuits, within and upon single semiconductor crystals.

Micrometer An instrument used for measuring extremely small distances. In the micrometer calliper, the object to be measured is held between the two jaws of the instrument; the distance between the jaws is measured on a scale calibrated to the rotation of the finely threaded screw that moves one of the jaws. In astronomical and microscopic micrometers, the distance that a filament moves from one end to the other of the image of an object is read on a calibrated scale.

Micron One micron equals 10-4 cm or may also be expressed as 10-6 meters. A unit of length, equal to the thousandth part of one millimetre. A particle with a diameter between 0.01 and 0 0001 millimetre.

Microorganism organisms (microbes) observable only through a microscope; larger, visible types are called macro organisms.

Microphone A device (invented c.1877) used in radio broadcasting, recording, and sound-amplifying systems to convert sound into electrical energy. Its basic component is a flexible diaphragm that responds to the pressure or particle velocity of sound waves. In a Capacitor, or condenser, microphone, used in high-quality sound systems, two parallel metal plates are given opposite electrical charges. One of the plates is attached to the diaphragm and moves in response to its vibrations, generating a varying voltage

Microsecond One millionth of a second, 10-6 second, expressed as msec.

Microwave Electromagnetic Radiation having a frequency range from 1,000 to 300,000 megahertz, corresponding to a wavelength range from 300 to 1 mm (about 12 to about 0.04 in.). Microwaves are used in Microwave Ovens, Radar, and communications links spanning moderate distances.

MIDI A method of computer control of firework displays in which cues are programmed like notes on a score. MIDI is an internationally recognised coding standard usually used for composing music.

Mild Detonating Fuse (MDF) A flexible metal tube, usually lead, containing a much smaller core of high explosive than the normal detonating cord. More accurately - miniature detonating fuse.

Military Gases A military gas is any agent or combination of agents that can produce either a toxic or irritating physiological effect. Such agents may be in solid, liquid, or gaseous state, either before or after dispersion. The military gas may be classed as persistent if it remains effective at its point of release for more than 10 minutes, or non-persistent if it becomes ineffective within 10 minutes. Military gases can be further classified according to their toxic and irritating effects.

milligrams per litre (mg/l) this is a weight per volume designation. 1mg/L = 1ppm.

Millisecond One thousandth of a second, 10-3 second, expressed as msec.

Mine - Mil. An encased explosive or chemical charge designed to be placed in position so that it detonates when its target touches it or moves in the vicinity.

Mine bag *see mortar mine*.

Mine - Fwk. Typically a complete firework with firing tube, but generally the firework itself.

Miniaturized Detonating Cord Detonating cord with a core load of 5 or less grains of explosive per foot.

Minimum Recommended Firing Current The lowest recommended electric current to ensure reliable performance of an electric detonator.

Mirror In optics, a reflecting surface that forms an image of an object when light rays coming from that object fall upon it Reflection. A plane mirror, which has a flat reflecting surface, reflects a beam of light without changing its character. In a convex spherical mirror, the vertex, or midpoint, of the mirror is nearer to the object than the edges, and parallel rays from a light source diverge after reflection. In a concave mirror, the vertex is farther away from the object than the edges, and rays parallel to the principal axis are reflected to a single point, or principal focus. A concave parabolic mirror is the principal element of a reflecting telescope.

Misfire 1) Failure to fire or explode properly. 2) Failure of a primer or the propelling charge of a projectile to function, wholly or in part. Misfire may be contrasted with hangfire, which is delay in any part of a firing charge. Misfires are usually difficult and dangerous to resolve and must be treated with respect.

Missile Any object thrown, dropped, fired, launched or otherwise projected with the purpose of striking a target. Short for "ballistic missile", "guided missile." (Missile is loosely used as a synonym for "rocket" or "spacecraft" by some careless writers.)

Misznay-Shardin A type of shaped charge, an explosive charge with special penetrating effects.

Mixture Usually synonymous with "composition", but may mean the list of ingredients of a composition.

Mockup A model (often crude) for study or training.

Mode The most frequent value in a series of measurements.

Modulation in communications, process in which some characteristic of a Wave (the carrier wave) is made to vary in accordance with an information-bearing signal wave (the modulating wave); demodulation is the process by which the original signal is recovered from the wave produced by modulation. In modulation the carrier wave is generated or processed so that its amplitude, frequency, or some other property varies. Amplitude modulation (AM), widely used in radio, is constant in frequency and varies the intensity, or amplitude, of the carrier wave in accordance with the modulating signal. Frequency modulation (FM) is constant in amplitude and varies the frequency of the carrier wave in such a way that the change in frequency at any instant is proportional to another time-

varying signal. The principal application of FM is also in radio, where it offers increased noise immunity and greater sound fidelity at the expense of greatly increased bandwidth. In pulse modulation the carrier wave is a series of pulses that are all of the same amplitude and width and are all equally spaced. By controlling one of these three variables, a modulating wave may impress its information on the pulses. In pulse code modulation (PCM) it is the presence or absence of particular pulses in the carrier stream that constitutes the modulation.

Mohaupt Effect The effect of a metal liner introduced in a shaped charge to increase penetration. Generally incorporated in Heat ammunition. Can include the use of Copper Foil tape. See Munroe Effect.

Molar a solution concentration, having one mole of solute per litre of solution.

Molarity a measure of solution concentration expressed in moles of solute per litre of solution.

Mole A mole in chemistry is a quantity of particles of any type equal to Avogadro's number (6.02252 + 1023). One gram-atomic weight (or one gram-molecular weight)-the amount of anatomic (or molecular) substance whose weight in grams is numerically equal to the Atomic Weight (or Molecular Weight) of that substance-contains exactly one mole of atoms (or molecules). For example, one mole, or 12.011 grams, of carbon contains 6.02252 + 1023 carbon atoms, and one mole, or 180.16 grams, of glucose ($C_6H_{12}O_6$) contains the same number of glucose molecules.
Molecular Weight is the weight of a Molecule of a substance expressed in atomic mass units (Atomic Weight). The molecular weight is the sum of the atomic weights of the atoms making up the molecule.

Molecule A molecule is the smallest particle of a Compound that has all the chemical properties of that compound. Molecules are made up of two or more Atoms, either of the same Element or of two or more different elements. Ionic compounds, such as common salt, are made up not of molecules but of ions arranged in a crystalline structure (Crystal). Unlike Ions, molecules carry no electrical charge. Molecules differ in size and Molecular Weight as well as in structure (Isomer).

Momentum in mechanics is the quantity of Motion of a body. The linear momentum of a body is the product of its mass and velocity. The angular momentum of a body rotating about a point is equal to the product of its mass, its angular velocity, and the square of the distance from the axis of rotation. Both linear and angular momentum of a body or system of bodies are conserved (Conservation Laws, in physics) if no external force acts on it or them.

Monopropellant A liquid propellant which contains an oxidizing agent and combustible matter (fuel) in a single phase.

Mortar mine A mine fired from a mortar.

Mortar The tube used to fire an aerial shell, or mine. Mortars can be constructed from paper, plastic, GRP or metal.

Mosaic The French term for splitting comet

Motion in Mechanics, the change in position of one body with respect to another. The study of the motion of bodies is called Dynamics. The time rate of linear motion in a given direction by a body is its velocity; this rate is called the speed if the direction is unspecified. If during a time t a body travels over a distance s, then the average speed of that body is s/t. The change in velocity (in magnitude and/or direction) of a body with

respect to time is its acceleration. The relationship between Force and motion was expressed by Isaac Newton in his three laws of motion: (1) a body at rest tends to remain at rest, or a body in motion tends to remain in motion at a constant speed in a straight line, unless acted on by an outside force; (2) the acceleration a of a mass m by a force F is directly proportional to the force and inversely proportional to the mass, or a = F/m; (3) for every action there is an equal and opposite reaction. The third law implies that the total Momentum of a system of bodies not acted on by an external force remains constant Conservation Laws). Motion at speeds approaching that of light must be described by the theory of Relativity, and the motions of extremely small objects (atoms and elementary particles) are described by quantum mechanics (Quantum Theory).

Motor (Rocket) A generic term for a solid propellant rocket consisting of the assembled propellant, case, ignition system, nozzle and appurtenances.

MS Connectors Non-electric, short-interval (millisecond) delay devices for use in delaying blasts that are initiated by detonating cord; Same as Detonating Cord .

Multibreak shell An aerial shell comprising more than one section producing a separate effect in sequence and ignited by the bursting of the preceding section. The public may incorrectly refer to a "shell of shells" as a multi-break effect.

Multiple Grain An assembly of solid propellant grains inside an explosive device or motor.

Multisection Charge Propelling charge in separate-loading or semi-fixed ammunition that is loaded into a number of powder bags. Range adjustments can be made by increasing or reducing the number of bags used, as contrasted with a single-section charge in which the size of the charge cannot be changed.

Multi-shot battery The generic term for a collection of pyrotechnic pieces lit at a single ignition point, but often used exclusively for items referred to as "cakes".

Munroe Effect The jetting effect of a shaped charge. When a liner is used, the effect is called "Mohaupt effect". The concentrated, explosive action, through the use of a shaped charge.

Mustard Gas A blister gas which acts as a cell irritant and cell poison. Contains about 30 percent sulphur impurities, giving it a pronounced odour.

Muzzle Blast Sudden air pressure exerted in the vicinity of the muzzle of a weapon by the rush of hot gases and air on firing.

Muzzle Brake - Mil. (Also called a Recoil Brake) Device attached to the muzzle of a gun which utilizes escaping gases to reduce the effective recoil force of the gun tube on the carriage or mount. In some designs, it eliminates or reduces muzzle flash.

Muzzle break, - Fwk. A malfunction of a shell where the bursting charge operates just as the shell leaves the mortar. This is a common point of shell failure as the pressure changes that act on the shell are great at this point.

Muzzle Flash Undesirable luminous ignition of unburned propellant gases issuing from the muzzle of a gun. The gases ignite upon mixture with atmospheric oxygen.

Muzzle Velocity Speed of a projectile at the instant it leaves the muzzle of a gun.

Muzzle Wave Compression wave or reaction of the air in front of the muzzle of a weapon immediately after firing.

N

Napalm A gasoline thickener.

Naphthalene [C10H8] A white crystalline powder with a tar like smell, melts at 80 degrees C. Dissolves in benzene. Used mainly in black smoke compositions.

National Campaign for Firework Safety ill-informed group whose directionless motives are a disguise for there desire to ban fireworks completely.

National Safety Council (NSC) An American non-profit organization setup by Congress to provide a regular information service on the causes of accidents and ways to prevent them.

Natural Gas natural mixture of flammable gases found issuing from the ground or obtained from specially driven wells. Largely a mixture of Hydrocarbons, natural gas is usually 80 to 95% Methane. The composition varies in different localities, and minor components may include carbon dioxide, nitrogen, hydrogen, carbon monoxide, and helium. Often found with Petroleum, natural gas also occurs apart from it in sand, sandstone, and limestone deposits. Natural gas began to be used as an illuminant and a fuel on a large scale in the late 19th century, when pipelines were built to provide it to large industrial cities. Liquified natural gas (LNG) is natural gas that has been cooled and pressurized to liquify it for convenience in shipping and storage.

Neon [Ne] gaseous element, discovered in 1898 by William Ramsay and M.W. Travers. A colourless, odourless, and tasteless inert gas, it emits a bright-red glow when conducting electricity in a tube. Neon is used in advertising signs, Lasers, Geiger counters, Particle Detectors, and high-intensity beacons. Liquid neon is a cryogenic refrigerant.

Neutral Burning The burning of a propellant grain in such a manner that the exposed surface area remains constant as burning progresses.

Neutralization chemical addition of either acid or base to a solution such that the pH is adjusted to 7.

Neutron An uncharged Elementary, discovered by James Chadwick in 1932, of slightly greater mass than the Proton. The stable isotopes of all elements except hydrogen and helium contain within the nucleus a number of neutrons equal to or greater than the number of protons. The preponderance of neutrons becomes more marked for very heavy nuclei. A neutron bound within the nucleus may be stable. A nucleus with an excess of neutrons, however, is radioactive; the extra neutrons (as well as any free neutrons not bound within a nucleus) convert by beta decay (Radioactivity) into a proton, an electron, and an antineutrino. The neutron and the proton are regarded by physicists, as two aspects, or states, of a single entity, the nucleon. The antineutron, the neutron's antiparticle (Antimatter), was discovered in 1956.

NG Nitroglycerin.

Nitric Acid [HNO3], colourless, highly corrosive, poisonous liquid that gives off choking fumes in moist air. It is miscible with water in all proportions. Commercially, it is usually available in solutions of 52% to 68% nitric acid in water. Solutions containing over 86% nitric acid are commonly called fuming nitric acid. Nitric acid is a strong oxidizing agent. It reacts with metals, oxides, and hydroxides, forming nitrate salts.

Nitrocellulose Explosive substance formed by the nitration of cotton, or some other form of cellulose. Used as the base of most U.S. propellants. Specific grades of nitrocellulose (Pyrocellulose or Guncotton) depend on the degree to which the cellulose is nitrated.

Nitrocellulose Lacquer [C6H7N3O11] A fast-drying, usually about 25% solution, flammable binder and waterproof coating for fuse. (nitrocellulose dissolved in acetone).

Nitrocotton Guncotton.

Nitrogen [N] a gaseous element, discovered by Daniel Rutherford in 1772. Nitrogen is a colourless, odourless, tasteless, diatomic gas that is relatively inactive chemically; it occupies about 78% (by volume) of dry air. Its chief importance lies in its compounds, which include Nitrous oxide, Nitric Acid, Ammonia, many Explosives, Cyanides, fertilizers, and proteins. Nitrogen is present in the protoplasm of all living matter; it and its compounds are necessary for the continuation of life.

Nitroglycerin An explosive chemical compound used as a sensitizer in dynamite and represented by the empirical formula **[C3H5N3O9].** Yellow oil. Detonation velocity, confined: 7600 m/s = 25,000 ft/s at r = 1.59 g/cm3. Oxygen balance: 13.5%, nitrogen content: 18.50%, volume of detonation gases 782 l/kg. On old boxes of dynamite it may appear as white or light grey crystals.

Nitroglycerne Nitrated ester of glycerol in which the OH radicals are replaced by N02; used as primary base of British propellants and as gelatinizing agent of U.S. propellants but not used as primary base of U.S. propellants because its high flame temperature accelerates bore erosion.

Nitroguanidine (Nitrated Aminomethanamidine) Used as an additional base of propellant; used as a "cool propellant" because of its low flame temperature which does not erode gun bores or produce as much luminous flash as single (nitrocellulose) propellants.

Nitromethane is sparingly soluble in water. The compound is of industrial interest as a solvent rather than as an explosive. Its technical synthesis involves nitration of methane with nitric acid above 400ÝC (750ÝF) in the vapour phase.

Nitrous Oxide [N2O], colourless gas with a sweetish taste and odour. Although it does not burn, it supports combustion because it decomposes into oxygen and nitrogen when heated. A major use is in dental anesthesia. It is often called laughing gas because it produces euphoria and mirth when inhaled in small amounts.

No. 8 Test Detonator has 0.40 - 0.45 g of PETN base charge pressed to a specific gravity of 1.4 g/cc and primed with standard weights of primer, depending on manufacturer.

Nobel-Abel Equation Derivation of perfect gas law - P max equals FD/1-aD where P rnax. equals maximum pressure, F equals force factor in psi - cc/gD equals loading density in g/cc and a equals co-volume factor in cc/g. Used in interior ballistic computations.

No-Fire Current Maximum current, which can be continuously applied to a bridgewire circuit without igniting the prime material. (Note that continued application of this current may degrade the prime and "dud" the unit.)

Noise mine A mine in which the principle effect is ejection of pyrotechnic noise units (e.g crackers or whistles)

Nomatch A specialised system for igniting fireworks using a shock tube. The advantage of Nomatch is the extremely high speed of propagation leading to almost simultaneous ignition of several pieces at great distances.

Non-Delay Fuse that functions as a result of inertia of firing pin (or primer) as missile is retarded during penetration of target. The inertia causes the firing pin to strike the primer (or primer the firing pin) initiating fuse action. This type of fuse is inherently slower in action than the superquick or instantaneous fuse, since its action depends upon deceleration (retardation) of the missile during penetration of the target.

Non-electric Detonator A detonator that does not require the use of electric energy or safety fuse to function.

Non-hygroscopic Does not absorb moisture from the air.

Non-sparking Metal A metal that will not produce a spark when struck with other tools, rock, or hard surfaces. Tools used in the firework trade are mainly brass although copper beryllium and certain stainless steel tools are now finding favour.

Normal a solution concentration of one gram equivalent per litre of solution.

Normal Charge Propelling charge employing a standard amount of propellant to fire a gun under ordinary conditions, as compared with a reduced charge or a supercharge used in special circumstances.

Normal Curve The idealized distribution of an infinite number of observations equally divided between favourable and unfavourable.

Normal Force Component of air resistance perpendicular to the axis of the projectile in the plane of yaw (exterior ballistics). Any force perpendicular to a given line or surface (general).

Normal Impact Striking of a projectile against a surface that is perpendicular to the line of flight of the projectile.

Normality a measure of solution concentration expressed in equivalent weights of solute per litre of solution.

Nuclear Energy is the energy stored in the nucleus of an Atom and released through fission, fusion, or Radioactivity. In these processes a small amount of mass, equal to the difference in mass before and after the reaction, is converted to energy according to the relationship E = mc2, where E is energy, m mass, and c the speed of light (Relativity). In fission processes, a fissionable nucleus absorbs a neutron, becomes unstable, and splits into two nearly equal nuclei. In fusion processes, two nuclei combine to form a single, heavier nucleus. Fission occurs for very heavy nuclei, while fusion occurs for the lightest nuclei. Nuclear fission was discovered in 1938 by Otto Hahn and Fritz Strassman, and was explained in 1939 by Lise Meitner and Otto Frisch. Fission energy can be obtained by bombarding the fissionable isotope Uranium-235 with slow neutrons in order to split it. Because this reaction releases an average of 2.5 neutrons, a chain reaction is possible, provided at least one neutron per fission is captured by another nucleus and causes a second fission. In an Atomic Bomb the number of neutrons producing additional fission is greater than 1, and the reaction increases rapidly to an explosion. In a Nuclear Reactor, where the chain reaction is controlled, the number must be exactly 1 in order to maintain a steady reaction rate. Uranium-233 and Plutonium-239 can also be used but must be produced artificially. Moreover, the fuel for fusion reactors, deuterium, is readily available in large amounts. Temperatures greater than 1,000,000ÝC are required to initiate a fusion, or thermonuclear, reaction. In the Hydrogen Bomb such temperatures are

provided by the detonation of a fission bomb. Sustained, controlled fusion reactions, however, require the containment of the nuclear fuel at extremely high temperatures long enough to allow the reactions to take place. At these temperatures the fuel is a Plasma, and magnetic fields have been used in attempts to contain this plasma. To produce fusion energy, scientists have also used high-powered laser beams aimed at tiny pellets of fission fuel. Once practical controlled fusion is achieved, it will have great advantages over fission as a source of energy.

Nuclear Physics The study of the components, structure, and behaviour of the nucleus of the Atom. It is especially concerned with the nature of matter and Nuclear Energy. The subject is commonly divided into three fields: low-energy nuclear physics, the study of Radioactivity; medium-energy nuclear physics, the study of the force between nuclear particles; and high-energy, or particle, physics, the study of the transformations among subatomic particles in reactions produced in a Particle Accelerator.

Nuclear Reactor A device for producing Nuclear Energy by controlled nuclear reactions. It can be used for either research or power production. The reactor is so constructed that the fission of atomic nuclei produces a self-sustaining nuclear chain reaction, in which the produced neutrons are able to split other nuclei. A fission reactor consists basically of (1) a fuel, usually uranium or plutonium, enclosed in shielding; (2) a moderator-a substance such as graphite, beryllium, or heavy water-that slows down the neutrons so that they may be more easily captured by the fissionable atoms; and (3) a cooling system that extracts the heat energy produced. The fuel is sometimes enriched-i.e., its concentration of fissionable isotopes is artificially increased-to increase the frequency of neutron capture. The breeder reactor is a special type of reactor that produces more fissionable atoms than it consumes by using surplus neutrons to transmute certain non-fissionable atoms into fissionable atoms. The design of fusion reactors is still in an experimental stage because of the problems involved in containing the plasma fuel and attaining the high temperatures needed to initiate the reaction.

O

Obturate To stop or close an opening so as to prevent escape of gas or vapour, to seal as in delay elements.

Obturation Any process that prevents the escape of gases from the tube of a weapon during the firing of a projectile.

Obturator A device for making the tube of a weapon gas-tight, preventing any escape of gas until the projectile has left the muzzle.

Octane Number a quality rating for Gasoline indicating the ability of the fuel to resist premature detonation and to burn evenly when exposed to heat and pressure in an Internal Combustion Engine. Premature detonation, indicated by knocking and pinging noises, wastes fuel and may cause engine damage. The octane number can be increased by varying the relative amounts of the different Hydrocarbons that make up the gasoline or by additives, e.g., tetraethyl lead. Federal regulations in the U.S. require commercial gasoline pumps to indicate the octane number, which is usually 87 or 89 for regular grade gasoline and 93 for premium grade. Since the early 1970s most Automobiles have been built to operate on low octane gasoline with little or no lead added.

Octol A mixture of Octogen (NMX) and TNT 70/30 and 75/25.

Ogive The shape of the head of the projectile, often a convex solid of revolution generated by an arc of a circle whose centre lies on the side of the axis of revolution opposite to the arc.

Ohm unit of electrical Resistance, defined as the resistance to the flow of a steady electric current offered by a column of mercury 14.4521 grams in mass with a length of 1.06300 m and with an invariant cross-sectional area, when at a temperature of 0ÝC.

Ohm meter A device for measuring the resistance of a circuit, and typically build into electrical firing panels. The current applied by the Ohm meter must be less that the no-fire current!

Ohm's Law where: V = voltage of power source I = current in amperes R = resistance of circuit in ohms (W)

Open circuit An electric circuit that is not complete - i.e will not fire when a current is applied.

Optics Scientific study of light. Physical optics is concerned with the genesis, nature, and properties of light; physiological optics with the part light plays in vision; and geometrical optics with the geometry involved in the reflection and refraction of light as encountered in the study of the mirror and the lens.

Orange book The United Nations book on the Classification and Testing of Dangerous Goods

Organic Chemistry branch of Chemistry dealing with Carbon compounds. Of all the elements, carbon forms the greatest number of different compounds; moreover, compounds that contain carbon are about 100 times more numerous than those that do not. Compounds containing only carbon and Hydrogen are called Hydrocarbons. Organic compounds containing Nitrogen are of great importance to Biochemistry. Organic chemistry is of importance to the petrochemical, pharmaceutical, and textile industries; in textiles a prime concern is the synthesis of new organic molecules and Polymers.

Organic liquid In our terms a solvent that is not based on water (e.g Acetone or Cyclohexanone)

Organic matter Chemical compounds based on carbon chains or rings, and also containing hydrogen with or without oxygen, nitrogen, or other compounds.

Oxalic Acid [C2H2O4] White granular powder used in making metal oxalates, can be extracted from Rhubarb crumble.

Oxidant The component of a firework composition that supplies the oxygen to the reaction (e.g Potassium Nitrate)

Oxidation in a broad sense oxidation is the increase in positive valence of any element in a substance. On the basis of the electron theory, oxidation is a process in which an element losses electrons. In a narrow sense, oxidation means the chemical addition of oxygen to a substance.

Oxidising agent A chemical agent that oxidizes.

Oxidizer or **Oxidizing Material** A substance, such as a nitrate, that readily yields oxygen or other oxidizing substance to stimulate the combustion of organic matter or other fuel.

Oxygen Balance 1) The percentage excess or deficiency of oxygen as compared to that required to convert the carbon in an explosive to CO and the hydrogen to HO.

2) The theoretical percentage of oxygen in an explosive material or ingredient that exceeds (+) or is less than (-) what is needed to produce ideal reaction products. The amount of oxygen, expressed in weight percent, liberated as a result of the complete conversion of the explosive material to CO2, H2O, SO2, Al2O2, etc. ("positive" oxygen balance). If the amount of oxygen bound in the explosive is insufficient for the complete oxidation reaction ("negative" oxygen balance), the deficient amount of the oxygen needed to complete the reaction is reported with a negative sign. Commercial explosives must have an oxygen balance close to zero in order to minimize the amounts of toxic gases, particularly carbon monoxide, and nitrous gases, which are involved in the fumes.

Ozone [O3] Oxygen in molecular form with three atoms of oxygen forming each molecule (O3). Atmospheric oxygen is molecular in form but each molecule contains only two atoms of oxygen. Ozone is formed, by passing high voltage electric charges, through dry air. The third atom of oxygen in each molecule of ozone is loosely bound and is easily released.

P

Palm burst The central burst, similar to a coconut shell, in a coloured shell. For instance a "Red peony with palm core"

Paraffin Wax white, semi-translucent, odourless, tasteless, water insoluble, waxy solid. Though relatively inert, it burns readily in air. A mixture of Hydrocarbons obtained from Petroleum during refining, paraffin wax is used in candles and for coating paper. In pyrotechnics it is used to coat reactive metal powders, it also reduces the sensitivity of compositions and aids the pressing of powders.

Parallax Any alteration in the relative apparent positions of objects produced by a shift in the position of the observer. Stellar parallax is the apparent displacement of a nearby star against the background of more distant stars resulting from the motion of the earth in its orbit around the sun; formally, the parallax of a star is the angle at the star that is subtended by the mean distance 1 Astronomical Unit between the earth and the sun. A star's distance (d) in parsecs is thus the reciprocal of its parallax (p) in seconds of arc (or d = 1/p). Friedrich Bessel measured (1838) the first stellar parallax (0.3 seconds of arc for the star 61 Cygni). Geocentric parallax, used to determine the distances of solar system objects, is measured similarly; the diameter of the earth, rather than that of its orbit, however, is used as the baseline.

Parallel circuit An electrical circuit in which the current is divided to pass through several igniters. Parallel circuits are less easy to test for line breaks and short circuits than series circuits.

Parlon™. (chlorinated rubber, Chlor-Rub™, Superchlon™, chlorinated isoprene). A white powder used as a chlorine(68%) donor (and fuel to enhance collared flames and as a binder (in go-getters, for instance). Solvents are acetone and xylene.

Particle Board A composition board made of small pieces of wood bonded together.

Parts per million (ppm) the unit commonly used to represent the degree of pollutant concentration where the concentrations are small. Larger concentrations are given in percentages. 1ppm = 1mg/L. In BOD analysis, the results are expressed in ppm, whereas in the suspended solids test, the values are expressed in percents. In air, ppm is usually a volume/volume ratio; in water, ppm represents a weight/volume ratio.

Paste The most common usage is that referring to the pasting of aerial shells to enhance the burst of the shells.

Pattern shell A shell, usually with many fewer stars than a chrysanthemum shell of the same calibre, whose burst patter in such that a pattern rather than a sphere of stars is produces. Pattern shells come in many levels of complexity, but perhaps the most pleasing is the simple single circle.

PBX Abbreviation for plastic bonded explosives. Of particular importance for tactical operations are the "sheet explosives" which are made with PETN or RDX, depending on the product.

P-Diazobenzeneslfonic Acid [C6H4NSO3N]

PE Abbreviation of "plastic explosives". They consist of high brisance explosives such as RDX or PETN combined with plasticizers.

Peat Soil-like material consisting of partially decomposed organic matter, formed by the

slow decay of aquatic and semiaquatic plants in Swamps and bogs. Principal types include moss peat, derived chiefly from Sphagnum and used as mulch and stable litter, and fuel peat, used where wood and coal are scarce. Peat is the first stage of transition from compressed plant growth to the formation of Coal.

Pellet An alternative term for a star, or a consolidated charge, usually restricted to pumped/pressed, cylindrical form, stars.

Pelleting Process of consolidating charges.

Pentolite An explosive composition of PETN and TNT, but usually a 50/50 composition. Can be melted and poured into cases.

Peony shell A typical style of shell in which the stars do not leave a trail of sparks.

Percussion A method of initiating an explosive item by a sudden sharp blow.

Percussion Composition High-explosive powder that is ignited in some types of firearms by the blow of the firing pin against the primer cap.

Percussion Fuse Impact Fuse.

Percussion Primer Cap or cylinder containing a small charge of high explosive that may be set off by a blow. A percussion primer is used in all fixed and semi-fixed ammunition and in certain types of separate-loading ammunition to ignite the main propelling charge.

Period a series of elements, arranged in order of atomic number represented by a horizontal row on the Periodic Table.

Periodic Table A chart that reflects the periodic recurrence of chemical and physical properties of the Elements when the elements are arranged in order of increasing Atomic Number. The periodic table was devised by Dmitri Mendeleev and revised by Henry Moseley It is divided into vertical columns, or groups, numbered from I to VIII, with a final column numbered 0. Each group is divided into two categories, or families, one called the a series (the representative, or main group, elements) the other the b series (the Transition Elements, or subgroup elements). All the elements in a group have the same number of Valence electrons and have similar chemical properties. The horizontal rows of the table are called periods. The elements of a particular period have the same number of electron shells; the number of electrons in these shells, which equals the element's atomic number, increases from left to right within each period. In each period the lighter Metals appear on the left, the heavier metals in the centre, and the non-metals on the right. Elements on the borderline between metals and non-metals are called metalloids. Elements in group Ia are called the Alkali Metals; in group IIa, the Alkaline-Earth Metals; in group VIIa, the Halogens; and in group 0, the Inert Gases.

Peripheral Test A brief test program conducted on an item or system to determine if it will meet only the most rigorous specified requirements.

Permissible Individual Maximum Pressure For any type gun, that value which should not be exceeded by the maximum pressure developed by an individual round under any service condition.

Petard Device intended to breach a door or gate.

PETN 1) An explosive compound, pentaerythritol tetranitrate represented by the empirical formula **[C5H8N4O12]** , it is a colourless crystal, with a molecular weight 316.1 and density of 1.76 g/cm3. Oxygen balance: -10.1%, nitrogen content: 17.72%,

volume of detonation gases 823 l/kg. Detonation velocity, confined: 8400 m/s = 27,600 ft/s at r = 1.70 g/cm3. Critical diameter of steel sleeve test: 6mm. Deflagration point: 202 ÝC = 396 F, impact sensitivity 3 N m. PETN is very stable, insoluble in water, sparingly soluble in alcohol, ether and benzene, and soluble in acetone and methyl acetate. 2) A high explosive of exceptional brisance, pentaerythrite tetranitrate. Used in detonating cord, boosters, detonators, blasting caps and as a constituent of Dentolite. in which it is mixed with TNT

Petroleum or crude oil, oily, flammable liquid that occurs naturally in deposits, usually beneath the surface of the earth. The exact composition varies according to locality, but it is chiefly a mixture of Hydrocarbons. Petroleum is a fossil fuel thought to have been formed over millions of years from incompletely decayed plant and animal remains buried under thick layers of rock. Drilling for oil is a complex, often risky process. Scientific methods are used to locate promising sites for wells, some of which must be dug several miles deep to reach the deposit. Many wells are now drilled offshore from platforms standing on the ocean bed. Usually the crude oil in a new well comes to the surface under its own pressure. Later it has to be pumped or forced up with injected water, gas, or air. Pipelines or tankers transport it to refineries, where it is separated into fractions, i.e., the portions of the crude oil that vaporize between certain defined limits of temperature. Fractions are obtained by a refining process called fractional Distillation in which crude oil is heated and sent into a tower. The vapours of the different fractions condense on collectors at different heights in the tower. The separated fractions are then drawn from the collectors and further processed into various petroleum products. Generally the fractions are vaporized in the following order: dissolved Natural Gas, Gasoline, naphtha, Kerosene, diesel fuel, heating oils, and finally tars. Lighter fractions, especially gasoline, are in greatest demand and their yield can be increased by breaking down heavier hydrocarbons in a process called cracking. The leading producers of petroleum in 1980 were the USSR, Saudi Arabia, the U.S., Iraq, Venezuela, China, Nigeria, Mexico, Libya, and the United Arab Emirates. The largest reserves are in the Middle East. Modern industrial civilization depends heavily on petroleum for motive power, fuel, lubrication, and a variety of synthetic products, e.g., dyes, drugs, and Plastics. The widespread burning of petroleum as fuel has resulted in serious problems of air pollution, and oil spilled from tankers and offshore wells has damaged oceans and coastlines. Unless the need for oil is reduced, conservationists may be unable to prevent the development of oil deposits whose exploitation poses threats to the environment.

Petroleum Jelly sometimes used in whistle compositions. Also used to seal water-absorbing crystals (such as hydroscopic fuels) or to lubricate mixes, which are mechanical pressed to aid its safe compaction.

PGI The American "Pyrotechnics Guild International"

pH range of numbers expressing the relative acidity or alkalinity of a solution. The pH value is the negative common Logarithm of the hydrogen-ion Concentration in a solution expressed in Moles per litre of solution. A neutral solution is one that is neither acidic nor alkaline such as pure water has a concentration of 10-7 moles per litre; its pH is thus 7. Acidic solutions have pH values ranging with decreasing acidity from 0 to nearly 7; alkaline or basic solutions have a pH ranging with increasing alkalinity from just beyond 7 to 14.

pH adjustment a means of maintaining the optimum pH through the use of chemical additives.

Phenolphthalein alkalinity a measure of the hydroxides plus one-half of the normal carbonates in aqueous suspension. Measured by the amount of sulphuric acid required to bring the water to a pH value of 8.3, as indicated by a change in colour of phenolphthalein. It is expressed in ppm of calcium carbonate (CaCO3).

Phosphorus [P] the red variety is used in the production of amorces and match striker surfaces. Compositions produced with this chemical should be treated with great caution as it can be very reactive and forms compositions which are very sensitive.

PIC Plastic Igniter Cord

Picric Acid (Trinitrophenol). High explosive, more powerful than trinitrotoluene, used widely in the form of mixtures with other nitro compounds.

Piezoelectric Crystal Crystalline material s constituted that, when it is mechanically compressed or stretched in certain directions, electrical charges in direct proportion to the mechanical strain appear on the crystal surfaces.

Pigeon A specialised type of novelty firework in which a rocket motor is forced to run horizontally along a wire or rope, usually accompanied by a whistling effect. Often, the pigeon will make the journey several times, first in one direction, then the other.

Pillbox star A star made from pressing (usually by hand) composition into a small thin-walled cardboard tube. Pill box stars are rarely made nowadays, but their effect can be dramatically different to round or pumped stars. Pill box stars usually have a longer burning duration that pumped or round stars.

Pin Puller A mechanical device in which a pressure cartridge causes a pin or piston to retract, usually against a side load.

Pin Pusher A mechanical device in which a pressure cartridge drives a pin or piston along its central axis.

Piobert's Law Expression of the linearity of burning of homogeneous propellants. As any exposed propellant surface receives heat from the surrounding combustion products at the same rate, it, therefore, burns at the same rate. The burning surface thus recedes by parallel layers.

Piped match Raw match enclosed in, usually, a paper tube used for transferring fire from one firework to another. Piped match also forms the leader of a shell.

Pistil In typical Japanese shells a central core to the burst of a contrasting or complementary colour to the main burst.

Pitch hard pitch is the residue from the distillation of coal tar. Sometimes used in the production of smokes and coloured lances, although possible impurities suggest its use with chlorates should be avoided.

Pitch (of rifling) Reciprocal of the twist.

Placards Signs placed on vehicles transporting hazardous materials (including explosive materials) indicating the nature of the cargo.

Plant The land, buildings, and machinery used in carrying on a trade or business.

Plastic any synthetic organic material that can be moulded under heat and pressure into a shape that is retained after the heat and pressures are removed. There are two basic types of plastic: thermosetting, which cannot be re-softened after being subjected to heat and pressures; and thermoplastic, which can be repeatedly softened and reshaped by heat and pressure. Plastics are made up chiefly of a binder consisting of long chainlike molecules called Polymers. Binders can be natural materials, e.g., Cellulose, or (more

commonly) synthetic Resins, e.g., Bakelite. The permanence of thermosetting plastics is due to the heat- and pressure-induced cross-linking reactions the polymers undergo. Thermoplastics can be reshaped because their linear or branched polymers can slide past one another when heat and pressure are applied. Adding plasticizers and fillers to the binder improves a wide range of properties, e.g., hardness, elasticity, and resistance to heat, cold, or acid. Adding Pigments imparts colour. Plastic products are commonly made from plastic powders. In compression moulding, heat and pressure are applied directly to the powder in the mould cavity. Alternatively, the powder can be plasticized by outside heating and then poured into moulds to harden (transfer moulding); be dissolved in a heating chamber and then forced by a plunger into cold moulds to set (injection moulding); or be extruded through a die in continuous form to be cut into lengths or coiled (extrusion moulding). The first important plastic, celluloid, has been largely replaced by a wide variety of plastics known by such trade names as Plexiglas, Lucite, Polaroid, and cellophane. New uses continue to be found and include contact lenses, machine gears, and artificial body parts. The widespread use of plastics has led to environmental problems. Because plastic products do not decay, large amounts accumulate as waste. Disposal is difficult because they melt when burned, clogging incinerators and often emitting harmful fumes, e.g., the hydrogen chloride gas given off by Polyvinyl Chloride. 1) High-brisance crystalline explosives, such as RDX or Octogen, can be embedded in curable or polyadditive plastics such as polysulfides, polybutadiene, acrylic acid, polyurethane, etc. The mixture is then cured into the desired shape. Other components such as aluminium powder can also be incorporated. The products obtained can be of any desired size, and specified mechanical properties can be imparted to them, including rubber-like elasticity (LX and PBX). They can also be shaped into foils. 2) "Plastic" ® also means mixtures of RDX with Vaseline or gelatinized liquid nitro compounds of plastiline-like consistency. Explosive which, within normal ranges of atmospheric temperature, is capable of being moulded into desired shapes. These explosives are easy to use by non-experts. 3) Also used with propellant charges for rockets and guns have also been developed by compounding solid explosives such as nitramines (e.g. Cyclonite) with plastics. Plastic explosives and plastic propellants are of interest, if low thermal and impact sensitivity is needed.

Plasticizer A material added to a propellant to increase flexibility or workability.

Plug Typically the closure of a mortar tube, but more generally the closure of any tube (e.g a Roman candle tube)

Plunging Fire Gunfire that strikes the earth’s surface at a high angle.

Plutonium [Pu] radioactive element, first produced artificially by Glenn Seaborg and colleagues in 1940 by deuteron bombardment of uranium oxide. It is a silver-grey Transuranium Element in the Actinide Series. Plutonium is a fission fuel for Nuclear Energy and weapons (Atomic Bomb; Nuclear Energy). It is an extremely dangerous poison, collecting in bones and altering the production of white blood cells.

Point Detonating Fuse located in the nose of a projectile, which is initiated upon impact.

Point-Blank Range Distance, to a target, that is so short that the trajectory of a bullet or projectile is practically a straight rather than a curved line.

Poka shell A weak busting shell of Japanese design commonly used for deploying parachutes or tissue-papered flags.

Polverone *see Pulverone*

Polyethylene (LDPE) **[(C2H4)n]** White powder. Possible use as fuel or binder.

-A chemical compound with high molecular weight consisting of a number of structural units linked together by covalent bonds. The simple molecules that may become structural units are themselves called monomers. A structural unit is a group having two or more bonding sites. In a linear polymer, the monomers are connected in a chain arrangement and thus need only have two bonding sites. When the monomers have three bonding sites, a nonlinear, or branched, polymer results. Naturally occurring polymers include cellulose, proteins, natural rubber, and silk; those synthesized in the laboratory have led to such commercially important products as Plastics, synthetic fibres, and synthetic rubber.

Polypropylene Lightweight Plastic, a Polymer or propylene. It is less dense than water and resists moisture, oils, and solvents. It is used to make packaging material, textiles, luggage, ropes that float, and, because of its high melting point (250ÝF/121ÝC), objects that must be sterilized.

Polyurethane Large group of Plastics that occur in a wide variety of forms. As a flexible foam, it is used for cushions and carpet backings. As a rigid foam, it can be moulded into furniture or used as insulation. Some polyurethane's are highly elastic, e.g., Lycra, a fibre used in stretch clothing; others form hard protective coatings.

Polyvinyl Chloride (PVC**) [(C2H3Cl)n]** A white powder used as a chlorine (57%) donor (coloured flame enhancer) and fuel and as a binder in some rocket propellants. Solvent is methylene chloride. Polyvinyl Chloride is a thermoplastic that is a Polymer of vinyl chloride. By adding plasticizers, hard PVC resins can be made into a flexible, elastic Plastic, used as an electrical insulator and as a coating for paper and cloth in making fabric for upholstery and raincoats.

Portfire Usually a thin-walled tube filled with slow burning composition used to ignite other fireworks. It is similar to a fusee, but its flame is usually less fierce and usually burns white. A test for a good portfire is that it should continue to burn after being dropped vertically onto its lit end at arm's length! DO NOT hold upright in an ungloved hand as the dross and sparks could seriously burn the skin!

Post A geographical position on a firing site used to identify the layout of the site. For instance, there may be 3 posts of Roman candles spread along the front of a site.

Potassium Benzoate [C6H5.CO.OK] Used in whistle mixes, and in rockets and burst compositions. A very lightweight white powder.

Potassium Chlorate [KClO3] A white powder. Used as an oxidizer in coloured flame compositions, an important component of primer formulations and pyrotechnical compositions, in particular matchheads and flash powders, and most commonly as the oxidizer in coloured smokes. Often contains 0.2% PCP anti-cake agent.

Potassium Dichromate (potassium bichromate). **[K2Cr2O7]** Orange granular powder. Used as a surface treatment to suppress the corrosion and reactivity of magnesium; infrequently as an oxidizer; and as a catalyst to aid in the decomposition of potassium perchlorate, often in primes. It does this by lowering the activation energy of the chemical reaction that takes place when the composition burns. That makes the star/comet, etc. ignite at a lower temperature. Potassium dichromate enables the oxidizer to part with its oxygen with a lower input of energy than would otherwise be needed.

Potassium [K], metallic element, discovered in 1807 by Sir Humphrey Davy, who decomposed potash with an electric current. It is a soft, silver-white, extremely reactive Alkali Metal. Potassium is the seventh most abundant element in the earth's crust and

the sixth most abundant of the elements in solution in the oceans. It is an essential nutrient for plants and animals. Potassium compounds are used in fertilizers, soaps, explosives, glass, baking powder, tanning, and water purification.

Potassium Nitrate (saltpetre) **[KNO3]** White powder with 0.05% TAG anti-cake. is readily soluble in water, sparingly soluble in alcohol, and insoluble in ether. It is used as a component in pyrotechnical compositions, in industrial explosives, and in black powder.

Potassium Perchlorate [KClO4] a fine white crystalline powder is insoluble in alcohol but soluble in water, decomposes at 400ÝC. It is prepared by reacting a soluble potassium salt with sodium perchlorate or perchloric acid. Whenever possible all chlorate compositions should reformulated to include the less sensitive perchlorate. Although perchlorate compositions are generally more difficult to ignite than similar chlorate mixes on no account should the use of sulphur be added to aid ignition.

Potassium Picrate [C6H2(NO2)3OK] fine yellow crystals, which decompose at @ 300ÝC as with all picrates it is sensitive to shock. Used for making whistles.

Potassium Sulphate [K2SO4] White powder used as a high temperature oxidizer in some white strobe compositions.

Potential, electric, work per unit electric charge expended in moving a charged body from a reference point to any given point in an electric field. The potential at the reference point is considered to be zero, while the reference point itself is usually chosen to be at infinity. The change in potential associated with moving a charged body is independent of the actual path taken and depends only on the initial and final points. Potential is measured in Volts and is sometimes called voltage.

Potentiometer, or voltage divider, manually adjustable variable electrical resistor that has a Resistance element attached to an Electric Circuit by three contacts, or terminals. The ends of the resistance element are attached to the two input voltage conductors of the circuit, and the third contact, attached to the output of the circuit, is usually a movable terminal that slides across the resistance element, dividing it into two resistors. Because the position of the movable terminal determines what percentage of the input voltage (Potential, Electric) is applied to the circuit, a potentiometer can be used to vary the magnitude of the voltage, e.g., in radio volume and television brightness controls.

Powder 1) An explosive (or propellant) in the form of powder or small granules.

2) A synonym designating any explosive, irrespective of type.

Powder Train 1) Train, usually of compressed black powder, used to obtain time action in older fuse types. 2) Train of explosives laid out for destruction by burning.

Power , in physics, the time rate of doing Work or of producing or expending Energy. The unit of power in the Metric System is the watt, which equals 1 joule per second. It is also the amount of power that is delivered to a component of an electric circuit when a current of 1 ampere flows through the component and a voltage of 1 volt exists across it. The English Unit Of Measurement is the horsepower, which equals 550 foot-pounds per second or 746 watts.

Power Source The source of power for energizing electric blasting circuits, e.g., a blasting machine or power line.

Power, electric, is the rate per unit of time at which Energy is consumed or produced. Electric Power is usually measured in watts or kilowatts (1,000 watts). The energy supplied by a current to an appliance enables it to work or to provide other forms of

energy such as light or heat. The amount of electric energy an appliance uses is found by multiplying its power rating by the operating time. Units of electric energy are usually watt-seconds (joules), watt-hours, or kilowatt-hours (the choice for commercial applications). Generally, practical electric-power-generating systems convert mechanical energy into electric energy (see Generator). Whereas some electric plants obtain mechanical energy from moving water (water power or hydroelectric power), the vast majority derive it from heat engines in which the working substance is steam generated by heat from combustion of fossil fuels or nuclear reactions (Nuclear Energy; Nuclear Reactor). Although the conversion of mechanical energy to electric energy may approach 100% efficiency, the conversion of heat to mechanical energy is about 41% efficient for a fossil-fuel plant and about 30% for a nuclear plant. It is thought that a magnetohydrodynamic generator, which operates by using directly the kinetic energy of gases produced by combustion, would have an efficiency of about 50%. Although Fuel Cells develop electricity by direct conversion of hydrogen, hydrocarbons, alcohol, or other fuels, with an efficiency of 50 to 60%, their high cost has restricted their use to space programs. Solar Energy has been recognized as a feasible power source. It can be exploited through wind turbines, Photovoltaic Cells, and heat engines, as well as through both conventional and low-head hydroelectric power plants. Research and development is bringing down the costs. An important problem in utilizing solar energy is related to the variable nature of sunlight and wind. To minimize energy losses from heating of conductors and to economize on the material needed for conductors, electricity is usually transmitted at the highest voltages possible. As modern Transformers are virtually loss free, the necessary steps upward or downward in voltage are easily accomplished. Electric utilities producing power are tied together by transmission lines into large systems called power grids. They are thus able to exchange power, so that a utility with low power demand can assist another with a high demand.

Practice Ammunition used for target practice; ammunition with a propelling charge, but with either an inert filler or a low-explosive filler to serve as a spotting charge.

Precession A change in the direction of the axis of a rotating body.

Precipitant a chemical or chemicals that cause a precipitate to form when added to a solution.

Precipitate the discrete particles of material separate from the liquid solution.

Precision The quality of having small dispersion about the mean.

Pre-ignition The spontaneous and premature ignition.

Premature Firing The detonation of an explosive charge before the intended time.

Press A machine used to fill composition into tubes *(e.g gerb press)*. Using a press has many advantages over ramming with a mallet, including consistency of results and reducing any hazard from shock and impact.

Pressure Cartridge An explosive item designed to produce momentary gaseous products of combustion under pressure for performing a mechanical operation.

Pressure When a force acts perpendicular to a surface, the pressure (p) exerted is the ratio between the magnitude of the force and the area of the surface: pressure = force / area Pressures are properly expressed in pascals, Pa (=N/m2), and may well be expressed using other terms such as bars, atmospheres or dynes.

Prills Cellular sub-globular particles of AN formed by spraying concentrated AN solution against a stream of air.

Primacord Flexible fabric tube containing a filler of high-explosive that is used to transmit a detonation from a detonator to a booster or bursting charge. Primacord is the trade name for one type of detonating fuse currently in use.

Primary Blast A term used in commercial blasting to describe a blast used to fragment and displace material from its original position to facilitate subsequent handling and crushing.

Primary Explosive 1) A sensitive explosive that nearly always detonates by simple ignition from such means, are spark, flame, impact, friction, or other primary heat sources of appropriate magnitude. 2) A sensitive explosive, one of the first elements in an explosive train.

Primary Fragmentation Fragments produced directly from the contents or casing of an explosive device.

Prime Often a slurry of blackpowder, a binder and water occasionally with added ingredients (e.g silicon) to increase the burning temperature used for ensuring ignition of reluctant compositions.

Primer or **Primer Mixture** An explosive mixture containing a sensitive explosive, usually the first element in an explosive train.

Primer 1) A unit, package, or cartridge of explosives used to initiate other explosives or blasting agents, and which contains, a detonator, or detonating cord to which is attached a detonator designed to initiate the detonating cord.

2) Device used to initiate the functioning of an explosive or igniter train. It may be actuated by friction, flow, heat, pressure or electricity.

Primer Seat Primer location within the breech chamber of a gun that uses separate loading ammunition.

Primer-Detonator Assembly consisting of a primer and a detonator. It may also include a delay element

Priming A process carried out to ensure ignition of a pyrotechnic composition when the composition itself is difficult to ignite. For instance, round stars are often primed for use in shells where the ignition time is short, whereas the same stars may be used without priming in a mine where the ignition time is longer.

Probability The ratio of the number of favourable events divided by the total number of events possible.

Probable Error An error of such magnitude that the probability of making an error greater than it in any given observation is just equal to the probability of making one less than it, both probabilities being one-half.

Probate Analysis A statistical analysis using a limited number of samples to determine a reliability factor. In this test, the level of variable is changed in a certain predetermined manner.

Procedure, Design Outline of steps to follow in designing an item.

Product Lot Sampling Tests conducted on a sample of a production lot to determine that the lot meets the specified dimensional and firing characteristics.

Progressive Burning The burning of a propellant grain in which the reacting surface area increases during the combustion.

Progressive Granulation Propellant grain which burns with a continually increasing surface until the grain is completely consumed.

Projectile Impact Sensitivity The projectile impact sensitivity is the reaction of an explosive charge if hit by infantry projectiles. Impact safety is given if the charge does not fully explode at impact. The projectile impact sensitivity does not only depend on the type of explosive itself, but also on the nature of its confinement (metallic, plastic, thin-walled, or thick-walled). A single bullet impact by an ordinary or a hard steel cored projectile, or a machine gun burst, will create different reactions.

Projectile Object, such as a bullet or shell, that is propelled from a weapon by an explosive propelling charge.

Proof Ammunition <bob> Ammunition incorporating solid, blunt-nosed, steel or cast iron shot of inexpensive manufacture; used in proof firing of guns; used to simulate the weight of projectile designed for the gun in adjusting the charge weight or propellant.

Propagation The detonation of explosive charges by an impulse received from adjacent or nearby explosive charges.

Propane [CH3CH2CH3] colourless gaseous Hydrocarbons that occurs in Natural Gas and Petroleum. Propane is sold compressed in cylinders, often mixed with other hydrocarbons, and is used as fuel in lamps, gas grills, certain home and portable stoves, and certain cigarette lighters.

Propellant An explosive material whose rate of combustion is low enough, and its other properties suitable, to permit its use as a propelling charge. A propellant may be either solid or liquid. A single base propellant composition consists primarily of matrix of nitrocellulose. A double base propellant composition contains nitrocellulose and nitroglycerine. A composite propellant composition contains an oxidizing agent in a matrix of binder.

Propellants 1) Explosive material whose rate of combustion is low enough, and its other properties suitable, to permit its use as a propelling charge.

2) An explosive substance or mixture of substances which, when burned, produces gases to provide energy. 3) Typically, a composition used in rocket motors which provide the force. In more general terms any composition used to propel a firework into the sky.

Propellant Actuated Device (PAD) A mechanical device actuated by a contained or inserted propellant charge.

Propellant compositions commonly contain additives which affect the performance of the propellant.

Propellant Double Base The double-base propellant consists of nitrocellulose and nitroglycerin with the addition of various stabilizers.

Propellant Explosive An explosive material that normally functions by deflagration and is used for propulsion purposes. It may be a Class A or Class B explosive, depending upon its susceptibility to detonation.

Propellents and Impulse Explosives These explosives are used to propel projectiles from guns, to propel rockets and missiles, launch torpedoes, and launch depth charges from

projectors. They are all burning or low explosive.

Propelling Charge Explosive charge that is burned in a weapon to propel a projectile there from (Propellant). Burning of the confined propelling charge produces gases whose pressure forces the projectile out.

Proper motion (M), apparent angular motion of a star on the celestial sphere, usually measured in seconds of arc per year. A star's transverse velocity VT i.e., its motion across the line of sight to the star (as opposed to its RADIAL Velocity, or line-of-sight velocity), is calculated in kilometres per second from the equation VT = 4.74 M/p , where p is the star's Parallax, expressed in seconds of arc.

Protein any of the group of highly complex organic compounds found in all living cells. Protein is the most abundant class of all biological molecules, comprising about 50% of cellular dry weight. Classified by biological function, proteins include the enzymes, which catalyse cellular reactions; collagen, keratin, and elastin, which are structural, or support, proteins; hemoglobin and other transport proteins; casein, ovalbumin, and other nutrient proteins; antibodies, which are necessary for immunity; protein hormones, which regulate metabolism; and proteins such as actin and myosin, the contractile muscle proteins, that perform mechanical work. Structurally, proteins are large molecules composed of one or more chains of varying amounts of the same 22 amino acids, which are linked by peptide bonds. Each protein is characterized by a unique and invariant amino acid sequence. Protein chains may contain hundreds of amino acids; some proteins also incorporate phosphorus or such metals as iron, zinc, and copper. The amino acid sequence also determines the molecule's three-dimensional structure; this so-called native state is required for proper biological function. The information for the syntheses of the specific amino acid sequences from free amino acids is carried by the cell's nucleic acids.

Proton Elementary Particle having a single positive electrical charge and constituting the nucleus of the ordinary hydrogen Atom. Every atomic nucleus contains one or more protons. The mass of the proton is about 1,840 times the mass of the Electron and slightly less than the mass of the neutron. In 1919 Ernest Rutherford discovered the proton as a product of the disintegration of the atomic nucleus. The proton and the neutron are regarded as two aspects, or states, of a single entity, the nucleon. The antiproton, the proton's antiparticle (Antimatter), was discovered in 1955.

Prototype The first fully workable item; also a precursor of later developments.

Pulverone Granulated rough powder (usually of the same composition as blackpowder) used as the bursting charge of a shell.

Pumped star A star produced by compressing composition in a mould. Pumped stars are usually cylindrical in form.

Punk Lighter A wick for lighting small fireworks. A type of Bullrush.

PVA Polyl Vinyl Acetate, known as "white glue", "Marvin Medium" or "Elmer's". A synthetic glue finding more and more use in pyrotechnics as opposed to the old fashioned starch-based and animal glues.

PVC Polyvinyl Chloride - one of many chlorine donors used as colour enhancing agents in firework compositions.

Pyro Powder Straight nitrocellulose powder; smokeless propelling charge consisting of a nitrocellulose that has a smaller nitrogen content than guncotton; single-base propellant.

Pyrocellulose Nitrocellulose containing 12.6% nitrogen.

Pyrocore A flexible explosive cord similar to MDF except that the high explosive core is modified to promote ignition at the speed of detonation. A high velocity ignition propagation fuse (detonating).

Pyrocotton Pyrocellulose.

Pyrogen A rocket ignition system containing a solid propellant gram as its main ignition material.

Pyrophoric substances can ignite spontaneously on contact with air, especially finely divided metals. When used in combination with oxidizers, it can be even more sensitive to static electricity and friction. It can be used in electrical igniters, and in situations where a hot spark is needed. Unusual care should be taken when using this particular material.

Pyrotechnic The generic term for any item (or composition) which reacts in a self-sustaining chemical reaction and is generally produces an effect of light, smoke, noise or heat. Pyrotechnic articles are classified differently to fireworks and the term is usually restricted to theatrical effects and specialised items such as mole smokes or thermite charges.

Pyrotechnic Substance - Military pyrotechnic Substances are used to send signals by visual means, such as colour, to illuminate areas of interest, to simulate other weapons or activities, and as ignition elements for certain types of weapons. Pyrotechnic compositions, with respect to rapidity of action, are low explosives because of their low rates of combustion. The functional characteristics of pyrotechnic compositions are their luminous intensity (candlepower), burning rate, colour, colour value, and efficiency of light production. Thus, for military use, pyrotechnic compositions must have acceptable explosive as well as burning characteristics. A military chemical agent is a substance that produces a toxic (casualty) or an irritating (harassing) effect, a screening smoke, and incendiary action, or a combination thereof. These agents include compounds and mixtures other than pyrotechnics and are used as fillers in artillery shell, mortar shell, grenades, rockets, and bombs. They are classified according to tactical use, physiological effect and purpose.

Pyrotechnics or **Pyrotechnic Compositions** A mixture of materials consisting essentially of an oxidizing agent (oxidant) and a reducing agent (fuel), that is capable of producing an explosive self sustaining reaction when heated to its ignition temperature; such as, but not limited to, devices used to produce sound, coloured lights or smokes for signalling, a bright light for illumination, and time delays.

Pyroxylin (Collodion) Nitrocellulose containing 8-12 percent nitrogen.

Q

Qualification Tests A series of tests conducted on an item or system to determine if it meets the requirements established for the specified use.

Qualified Means one who, by possession of a recognized degree, certificate, or professional standing, or who by extensive knowledge, training, and experience, has successfully demonstrated his ability to solve or resolve problems relating to the subject matter, the work or the project.

Quality Assurance System of assuring that material accepted is in accordance with requirements, including inspection and test procedures, acceptance criteria, etc.

Quantitative analysis chemical determination of the amounts or proportions of constituents in a substance.

Quantity - Distance Table A table listing minimum recommended distances from explosive materials stores of various weights to a specific location.

Quantum Theory, modern physical theory that holds that energy and some other physical properties often exist in tiny, discrete amounts. The older theories of classical physics assumed that these properties could vary continuously. Quantum theory and the theory of Relativity together form the theoretical basis of modern physics. The first contribution to quantum theory was the explanation of blackbody radiation in 1900 by Max Planck, who proposed that the energies of any harmonic oscillator are restricted to certain values, each of which is an integral multiple of a basic minimum value. The energy E of this basic quantum is directly proportional to the frequency n of the oscillator; thus E = hn, where Planck's constant h is equal to 6.63 x 10-34 J-sec. In 1905 Albert Einstein, in order to explain the Photoelectric Effect, proposed that radiation itself is also quantized and consists of light quanta, or Photons, that behave like particles. Niels Bohr used the quantum theory in 1913 to explain both atomic structure and atomic spectra. The light or other radiation emitted and absorbed by atoms is found to have only certain frequencies (or wavelengths), which correspond to the absorption or emission lines seen in atomic spectra (Spectrum). These frequencies correspond to definite energies of the photons and result from the fact that the electrons of the atoms can have only certain allowed energy values, or levels. When an electron changes from one allowed level to another, a quantum of energy is emitted or absorbed whose frequency is directly proportional to the energy difference between the two energy levels E1 and E2; thus E2 - E1 = hv. Quantum mechanics, the application of the quantum theory to the motions of material particles, was developed during the 1920s. In 1924 Louis de Broglie proposed that not only does light exhibit particle-like properties but also particles may exhibit wavelike properties. The observation, by Clinton Davisson and Lester Germer in a 1927 experiment that the diffraction of a beam of electrons is analogous to the diffraction of a beam of light confirmed this hypothesis. A particularly important discovery of the quantum theory is the uncertainty principle, enunciated by Werner Heisenberg in 1927; it places an absolute, theoretical limit on the combined accuracy of certain pairs of simultaneous, related measurements.

Quasar or quasi-stellar object, one of a class of faint blue celestial objects, starlike in appearance, that are currently believed to be the most distant and most luminous objects in the universe. The spectral lines of quasars have enormous Red Shifts that seem to imply that they are receding from our galaxy with speeds as great as 80% of the speed of light. If Hubble's Law for the expansion of the universe is extrapolated to include quasars, they may be as far as 8 billion Light-Years away and consequently as luminous intrinsically as 100 galaxies combined.

Quickmatch *see Raw match*

R

Rack An apparatus, usually for firing rockets. The term may also be applied to "racks" of mortars.

Radiation is the emission or transmission of energy in the form of Waves through space or through a material medium; the term also applies to the radiated energy itself. The term includes electromagnetic, acoustic, and particle radiation, and all forms of ionising radiation. According to Quantum Theory Electromagnetic Radiation may be viewed as made up of Photons. Acoustic radiation is propagated as sound waves. Examples of particle radiation are alpha and beta rays in Radioactivity, and Cosmic Rays.

Radiation Sickness is the illness caused by the effects of radiation on body tissues. It may be acute, delayed, or chronic and may occur after repeated (cumulative) exposure to small doses of radiation (as in a plant, a laboratory, or the environment); undue exposure to solar radiation; or exposure to a nuclear explosion. Symptoms may be mild and transitory, or severe, depending on the type of radiation, the dose, and the rate at which exposure is experienced. They include weakness, loss of appetite, vomiting, diarrhoea, a tendency to bleed, increased susceptibility to infection, and-in severe cases-brain damage and death. Mild radiation sickness is a common side effect of radiation therapy for Cancer. Exposure to radiation is of concern even in small doses because of possible long-term genetic effects.

Radical an atom or group of atoms with at least one unpaired electrons.

Radio Frequency Energy (RF) The energy transferred by electromagnetic wave in the radio frequency spectrum.

Radio Frequency Transmitter An electronic device that radiates radio frequency waves; the device may be fixed (stationary) or mobile.

Radio Waves The use of electromagnetic waves in the approximate frequency range from 10 kilocycles/second to 300,000 megacycles/second to transmit or receive electric signals without wires connecting the points of transmission and reception.

Radio, transmission or reception of Electromagnetic Radiation in the radio frequency range from one place to another without wires. For the propagation and interception of radio waves, a transmitter and receiver are employed. A radio wave carries information-bearing signals; the information may be encoded directly on the wave by periodically interrupting its transmission (Telegraph) or impressed on the carrier frequency by a process called Modulation, e.g., amplitude modulation (AM) or frequency modulation (FM). In its most common form, radio transmits sounds (voice and music) and pictures (Television). The sounds (or images) are converted into electrical signals by a Microphone (or camera tube), amplified (Amplifier), and used to modulate a carrier wave that has been generated by a transmitter. The modulated carrier is also amplified, then applied to an Antenna that converts the electrical signals to electromagnetic waves that radiate into space at the speed of light. Receiving antennas intercept part of this radiation, convert it back into electrical signals, and feed it to a receiver. Once the basic signals have been separated from the carrier wave, they are fed to a Loudspeaker or Cathode-Ray Tube, where they are converted into sound and visual images, respectively. Some celestial bodies and interstellar gases emit relatively strong radio waves that are observed with radio telescopes composed of very sensitive receivers and large directional antennas (Radio Astronomy). Long-range radio signals enable communications between astronauts and ground-based controllers and carry information from Space Probes as they travel to and encounter distant planets. The invention of the Transistor and other microelectronic devices (Micro) led to the development of portable transmitters and

receivers. Military applications of radio include the proximity fuse and various types of Reconnaissance Satellites. Citizens band (CB) radios, operating at frequencies near 27 megahertz, are used in vehicles for communication while travelling.

Radioactivity, the spontaneous disintegration or decay of the nucleus of an atom by emission of particles, usually accompanied by Electromagnetic Radiation. Natural radioactivity is exhibited by several elements, including Radium and Uranium. The radiation produced is of three types: the alpha particle, which is a nucleus (two protons and two neutrons) of an ordinary helium atom; the beta particle, which is a high-speed electron or, in some cases, a positron (the electron's antiparticle); and Gamma Radiation, which is a type of electromagnetic radiation with very short wavelengths. The rate of disintegration of a radioactive substance is commonly designated by its half-life, which is the time required for one half of a given quantity of the substance to decay. Radioactivity may be induced in stable elements by bombardment with particles of high energy.

Radium [Ra] is a radioactive metallic element, discovered in Pitchblende in 1898 by Pierre and Marie Curie. It is a rare, lustrous, white Alkaline-Earth Metal that resembles barium in its chemical properties. Radium compounds are found in uranium ores. The Radioactivity of radium and its compounds is used in the treatment of cancer. Radium compounds are mixed with a phosphor in luminous paints. In its radioactive decay, radium emits alpha, beta, and gamma rays and produces heat.

Radon [Rn] gaseous radioactive element, discovered by Ernest Rutherford in 1899. A colourless, chemically un-reactive Inert Gas, it is the densest gas known. Highly radioactive (emitting alpha rays), it is used chiefly in the treatment of cancer by radiotherapy. In homes and other buildings in some areas of the U.S. radon produced by the radioactive decay of uranium-238 present in soil and rock can reach levels regarded as dangerous, but the seriousness of the problem is unclear.

Rain Usually Silver rain or Gold Rain, in modern fireworks the long lasting stars from a shell or rocket that fall all the way to the ground. Care must be taken in the use of rain shells. In older terminology a "Golden Rain" was a particularly attractive type of hand held fountain.

Ram

1) To push into position.

2) To seal a projectile in the bore of a gun. 3)The rod which is used to compress powder within a tube. The ram is usually quite a tight fit to the tube.

Rammer

1) Device for driving a projectile into position in a gun. It may be hand- or power-operated or a part of the receiver mechanism.

2) Tool used to remove live projectiles from the bore of a gun.

Ramming The process of filling a firework case with composition. Ramming is usually applied to a mechanical process rather than to a manual process.

Random Sample selected without bias or prejudice.
Range The difference between the smallest and largest measurements in the sample.

Rare Earth Oxides of the Rare-Earth Metals The name of an earth is formed from the name of its element by replacing -um with -a. Once thought to be very scarce, they are widely distributed and fairly abundant in the earth's crust. Rare-earth minerals include bastnasite, cerite, euxenite, gadolinite, monazite, and samarskite. Mixed rare earths are

used in glassmaking, ceramic glazes, and glass-polishing abrasives, and as catalysts for petroleum refining. Individual purified rare earths are used in lasers and as colour-television picture-tube phosphors.

Rare-Earth Metals Group of chemical elements including those in the Lanthanide series, usually yttrium, sometimes scandium and thorium, and rarely zirconium. Promethium, which is not found in nature, is not usually considered a rare-earth metal. The metals occur together in minerals as their oxides Rare Earths and are difficult to separate because of their chemical similarity. The cerium metals are a subgroup, consisting of the elements with atomic numbers between 57 and 63 and ytterbium.

Raw match Blackpowder coated thread used for linking fireworks.

RDF (Reinforced Detonating Fuse) Frequently applied to reinforced MDF.

RDX (Cyclotrimethylenetrinitramine) Secondary high explosive used extensively by the military. A high explosive compound, the term RDX originated as an acronym for research development explosive by the U.S. military. In reality RDX is Cyclotrimethylenetrinitramine - for short cyclonite and is expressed as the empirical formula **[C3H6N6O6].** Cyclonite is a colourless crystal, with a molecular weight of 222.1, density of 1.82 g/cm3, oxygen balance: -21.6%, nitrogen content: 37.84%, volume of detonation gases: 900 l/kg. Detonation velocity, confined: 8,750 m/s = 28,700 ft/s at r = 1.76 g/cm3. Critical diameter of steel sleeve test: 8mm, impact sensitivity 7.5 N m. RDX is very stable, insoluble in water, sparingly soluble in alcohol, ether and benzene, and soluble in acetone. Cyclohexanone, nitrobenzene and glycol are solvents at elevated temperatures. RDX is probably the most important high-brisance explosive; its brisant power is owed to its high density and high detonating velocity. It is relatively insensitive (as compared to PETN - an explosive of similar strength). Its performance properties are only slightly inferior to those of the homologous Octogen (HMX).

Reagent a chemical substance used to cause a reaction for the purpose of chemical analysis.

Recommended Firing Current (Or Energy) In an EED, the current (or energy) which must be applied to a bridge circuit to cause operation within a specified time.

Recommended Test Current (Or Energy) In an EED, the current (or energy) that can be applied to a bridge circuit for extended periods without degrading the explosive material or firing device.

Red Gum (acaroides or yacca resin) [85% para-coumaric ester of xanthoresinotannol] Reddish brown, air-milled powder used as a fuel and binder. Natural vegetable gum whose solvent is alcohol.

Reducing agent The chemical role of a fuel in a firework composition. As the oxidising agent oxidises the fuel, the fuel can be said to reduce the oxidant.

Reduction chemical reaction in which an atom or molecule gains an electron; decrease in positive valence; addition of hydrogen to a molecule.

Refraction the deflection of a wave on passing obliquely from one transparent medium into a second medium in which its speed is different, as the passage of a light ray from air into glass. The index of refraction of a transparent medium is equal to the ratio of the speed of light in a vacuum to the speed of light in the medium. Snell’s law states that the ratio of the sine of the angle i of incidence (angle between the incident ray and the normal, or line perpendicular to the boundary between the two mediums at the point of

refraction) to the sine of the angle r of refraction (angle between the refracted ray and the normal) is equal to the ratio of the refracting medium's index of refraction nr to the original medium's index of refraction ni.

Refractory Very resistant especially to high temperatures; refractive pertains to optics.

Regenerative Cooling A system for keeping liquid rocket engines cool in which one of the liquid propellants is circulated through the engine thrust chamber walls to protect the metal of the walls from melting under high combustion temperatures.

Regressive Burning of a propellant grain in such a manner that the surface area decreases as burning progresses.

Relative Force Ratio of observed maximum pressure developed by a propellant under test to the maximum pressure developed by a standard propellant under identical test conditions.

Relativity, physical theory, introduced by Albert Einstein, that discards the concept of absolute motion and instead treats only relative motion between two systems or frames of reference. Space and time are no longer viewed as separate, independent entities but rather as forming a four-dimensional continuum called Space Time. In 1905 Einstein enunciated the special relativity theory, in which the hypothesis that the laws of nature are the same in different moving systems also applies to the propagation of light, so that the measured speed of light is constant for all observers regardless of the motion of the observer or of the source of light. From these hypotheses Einstein reformulated the mathematical equations of physics. In most phenomena of ordinary experience the results from the special theory approximate those based on Newtonian dynamics, but the results deviate greatly for phenomena occurring at velocities approaching the speed of light. Among the assertions and consequences of the special theory are the propositions that the maximum velocity attainable in the universe is that of light; that mass increases with velocity; that mass and energy are equivalent; that objects appear to contract in the direction of motion; that the rate of a moving clock seems to decrease as its velocity increases; that events that appear simultaneous to an observer in one system may not appear simultaneous to an observer in another system. Einstein expanded the special theory of relativity into a general theory (completed in 1915) that is principally concerned with the large-scale effects of Gravitation. The general theory recognizes the equivalence of gravitational and inertial mass, and asserts that material bodies produce the curvature of the space-time continuum and that the path of a body is determined by this curvature. The theory predicts that a ray of light is deflected by a gravitational field; observations of starlight passing near the sun, first made by Arthur Eddington and colleagues during a 1919 eclipse of the sun, confirmed this. The theory also predicts a Red Shift of spectral lines of substances in a gravitational field, a result confirmed by observation of light from white dwarf stars. Finally, the theory also accounts for the entire observed perihelion motion of the planet Mercury, only part of which could be explained by Newtonian Celestial Mechanics.

Relay, (explosive) An element of a fuze explosive train which augments an outside and otherwise inadequate output of a prior explosive component so as to reliably initiate a succeeding train component. Relays, in general, contain a small single explosive charge such as lead azide and are not usually employed to initiate high explosive charges.

Relay, electromechanical Switch in which the variation of current in one Electric Circuit controls the flow of electricity in another circuit. A relay consists of a movable contact connected to an Electromagnet by a spring. When the electromagnet is energized by the controlling current, it exerts a force on the contact that overcomes the pull of the spring and moves the contact so as to either complete or break a circuit. When the electromagnet is de-energized, the contact returns to its original position.

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Reliability A statistical evaluation of the probability of a device performing its design function.

Repeater shell Usually a cylinder shells with several different coloured bursts at regular intervals. See Multibreak shells.

Resin any of a class of amorphous solids or semisolids. Natural resins occur as plant exudations (e.g., of pines and firs), and are also obtained from certain scale insects. They are typically yellow to brown in color, tasteless, and translucent or transparent. Oleoresins contain essential oils and are often sticky or plastic; other resins are exceedingly hard, brittle, and resistant to most solvents. Resins are used in varnish, shellac, and lacquer and in medicine. Synthetic resins, *e.g., bakerlite*, are widely used in making Plastics.

Resins Usually applied to binding agents soluble in organic solvents *e.g Acaroid resin*

Resistance The property of an electric conductor by which it opposes flow of electricity and dissipates electrical energy away from the Electric Circuit, usually as heat. Resistance is basically the same for alternating- and direct-current circuits. A high-frequency alternating current, however, tends to travel near the surface of a conductor. Because such a current uses less of the available cross section of the conductor, it meets with more resistance than direct current. The unit of resistance is the OHM. In electrical firing of fireworks the resistance of a line is measure to prevent accidental "open" or "short" circuits.

Resistor Two-terminal Electric Circuit component that generates heat by offering opposition to an electric current. The most common forms of resistors are made from fine wires of special alloys wound onto cylindrical forms or from a moulded composition material containing carbon and other substances in varying amounts. Resistors are rated for the maximum amount of power that they can safely handle.

Restricted Area Any area, from which personnel, aircraft and/or vehicles, other than required for operations, are excluded for reasons of safety and security.

Restricted Burning Rate A solid propellant grain in which certain surfaces are restricted or inhibited to provide particular burning characteristics.

Retrofit A partial change in older equipment.

Retrorocket A rocket fired in a direction opposite to the line of flight of the vehicle to which it is attached.

Rice Hulls Often used coated with a burst-powder (gunpowder), to break shells cases, due to the increased surface area of explosive to weight ratio. The hulls, without the burst powder, weigh @ 4lbs for about 5 gallons in volume.

Ricochet Glancing rebound of a projectile after impact.

Rifle 1) Any firearm that has rifling in the bore designed to give a spin to the projectile for greater accuracy of fire and longer range (not extensively used in this manner, except for shoulder arms). 2) To cut spiral grooves (rifling) in the bore of a gun in order to give a spin to the projectile so that it will have a greater accuracy of fire and longer range.

Rifling Spiral grooves in the bore of a weapon designed to give a spin to the projectile for greater accuracy. Rifling includes both the grooves and the ridges between, called lands.

Ring shell An aerial shell that produces a symmetric ring of stars on bursting. Ring shells often are stabilised in flight with a rope "tail" to control the orientation of burst.

Rising effect Often synonymous with "tail effect", but may also be applied to shells in which, for instance, whistles or small shells (rising flowers) have been attached and which function on the shell's ascent.

Rocket, Fwk. A aerial device propelled into the air by a pyrotechnic motor which usually explodes the separate "head", containing coloured stars, reports or various F/X's.

Rocket, Mil. A missile containing combustibles, independent of atmospheric oxygen, which on being ignited, liberate gases producing thrust.

Rocket cone A device for firing flight rockets usually made from sheet steel curved into the characteristic cone shape.

Rocket motor The power unit of a rocket, typical manufactured nowadays by pressing blackpowder into a choked tube without a spindle. Rocket motors occasionally find other uses in pyrotechnics - as wheel drivers, and as short duration fountains.

Rocket Propellant Any agency used for consumption or combustion in a rocket and from which the rocket derives its thrust, such as a fuel oxidizer, additive, catalyst, or any compound or mixture of these. "Rocket propellant" is often shortened to "propellant."

Rocket rack A rack, usually made of wood or metal, for mounting many rockets prior to firing.

Rocket spindle The spike (usually metal) used to form the older type of pressed rocket motors with a central cavity for increased surface area and burning pressure.

Roman candle A tube, usually cardboard, in which several charges are loaded, each with their own delay fuse and lifting charge, which function in a sequential manner.

Rope (as it pertains to ballistics) Electromagnetic wave reflectors consisting of long strips of metal foil. Similar to window or chaff, but longer. Dropped from planes or shot into the air in projectile, a small parachute or other device may be attached to each strip to reduce rate of fall.

Rosin (Pine rosin, colophony). Tan to brown powder used as a fuel sometimes in blue colours and smokes. Solvents are alcohol and acetone.

Round
1) All the parts that make up the ammunition necessary in firing one shot (also called Complete Round).

2) One shot fired by a weapon.

Round Of Ammunition Round.

Round shell An aerial shell in the form of a sphere. Round shells usually contain coloured stars.

Round star A star prepared by rolling, thus applying layer upon layer of composition onto a central core.

Roundel shell An aerial shells comprising several maroons that burst in a ring pattern one after another

Rubber any solid substance, usually elastic, that can be vulcanized to improve its elasticity and add strength; the term includes natural rubber, or caoutchouc, and a wide variety of synthetic rubbers, which have similar properties. Rubbers are composed chiefly of Carbon and hydrogen, but some synthetics also have other elements, e.g., chlorine, fluorine, nitrogen, or silicon. All are compounds of high molecular weight; each consists of a series of one kind of molecule (e.g., isoprene in natural rubber) hooked together in a long chain to form a very flexible, larger molecule, the Polymer. Natural rubber is obtained as latex, a milky suspension of rubber globules found in a large variety of plants, chiefly tropical and subtropical. An important source is the Para Rubber Tree. Latex can be shipped for processing either as a liquid or coagulated by acid and rolled into sheets. For most purposes rubber is ground, dissolved in a solvent, and compounded with other ingredients, e.g., fillers, Pigments, and plasticizers. Known by pre-Columbian Indians of South and Central America, rubber first attracted interest in Europe in the 18th cent. Vulcanization, a process invented (1839) by Charles Goodyear revolutionized the rubber industry. It usually involves heating raw or compounded rubber with Sulphur, causing sulphur bridges to form between molecules. The product is non-sticky, elastic, and resistant to heat and cold. Natural rubber is used chiefly to make tires and inner tubes because it is cheaper than synthetic rubber and has greater resistance to tearing when hot. Natural rubber can be treated to make foam rubber and sponge rubber. The first synthetic rubber was made in Germany in World War I. Today synthetics, e.g., Buna S, neoprene, butyl, and nitrile, account for most of the world's rubber production. Made from Coal, Petroleum, Natural Gas, and Acetylene, synthetic rubbers are resilient over a wider temperature range than natural rubber and are more resistant to aging, weathering, and attack by certain substances, notably, oil, solvents, oxygen, and ozone. Silicone rubbers are used in insulation. Polyurethane is used in tyres, in shoes, and as foams. Neoprene is used for making hose and tank linings. Butyl rubber is used in inner tubes and as insulation.

S

Safe And Arm A device for interrupting (making safe) and aligning (arming) an explosive train.

Safe current The current level that it is safe to test an electric igniter without ignition.

Safety area The area around a display site, usually not including the fall out area which is considered separately.

Safety cap *see Fuse cover*

Safety Fuse A flexible cord containing an internal burning medium by which fire or flame is conveyed at a continuous and uniform rate from the point of ignition to the point of use, designed for commercial blasting similar to Bickford fuse.

Safety Standard Suggested precautions relative to the safety practices to be employed in the manufacture, transportation, storage, handling, and use of explosive materials.

Safety Wire set into the body of a fuse to lock all movable parts into safe position so that the fuse will not be set off accidentally. It is pulled out just before loading.

Salicylic Acid. (benzoic acid, 2-hydroxy-) **[C7H603]** White powder used in making salicylates.

Salinity 1) the relative concentration of salts, usually sodium chloride, in a given water. It is usually expressed in terms of the number of ppm of chloride.

2) a measure of the concentration of dissolved mineral substances in water.

Salt A chemical compound (other than water) formed by neutralization reactions between Acids and Bases; by direct combination of metal with non-metal, e.g., sodium chloride (common table salt); by reaction of a metal with a dilute acid; by reaction of a metal oxide with acid; by reaction of a non-metallic oxide with a base; or by reaction of two salts with each other to form two new salts. Most salts are ionic compounds. The chemical formula indicates the proportion of atoms of the elements making up the salt. A salt is classified as acidic, basic, or normal if it has, respectively, hydrogen (H), hydroxyl (OH), or neither in its formula. A salt undergoes dissociation when dissolved in a polar solvent, e.g., water

Saltpeter or potassium nitrate, chemical compound [KNO3] occurring as colourless prismatic crystals or as a white powder. When heated, it decomposes to release oxygen. Saltpeter has been used in gunpowder manufacture since about the 12th century, it is also used in explosives, fireworks, matches, and fertilizers, and as a food preservative.

Salute American term for maroon.

Sample That fraction of the population that is to undergo testing. Something to be analysed.

Saran™ Resin (polyvinylidine chloride) [(C2H2Cl2)n] Off-white granular powder used as a chlorine (73%) donor (coloured flame enhancer) and fuel. Solvent is xylene or acetone. Easily milled to fine powder.

Satellite, artificial An object launched by a Rocket into orbit around the earth or, occasionally, another solar-system body (Space Probe). A satellite in circular orbit at an

altitude of 22,300 mi (35,880 km) has a period of exactly 24 hr, the time it takes the earth to rotate once on its axis; such an orbit is called synchronous. If such an orbit also lies in the equatorial plane, it is called geostationary, because the satellite will remain stationary over one point on the earth's surface. The first artificial satellite, Sputnik 1, was launched by the USSR on Oct. 4, 1957. Explorer 1, the first American satellite, was launched on Jan. 31, 1958. The principal types of applications satellites are Communications Satellites, Navigation Satellites, Reconnaissance Satellites and Weather Satellites. Major U.S. scientific research satellites include the Orbiting Astronomical Observatories (OAO), the Orbiting Geophysical Observatories (OGO), the Orbiting Solar Observatories (OSO), the High Energy Astronomical Observatories (HEAO), many Explorer satellites, the Solar Maximum Mission (SMM), and the forthcoming Space Telescope. Major Soviet space-science satellite programs include Elektron, Proton, Prognoz, and many Cosmos satellites. The U.S. has also launched several Landsat satellites to survey the earth's resources by means of special television cameras and radiometric scanners.

Satellite, natural A celestial body orbiting a planet. The earth's only satellite is the MOON; thus satellites of other planets are often referred to as moons. The largest in the solar system is Jupiter's Ganymede, whose radius of 1,639 mi (2,638 km) is larger than that of the planet Mercury.

Saturated

1) in organics, a chemical compound with all carbon bonds satisfied; it does not contain double or triple bonds and thus cannot add elements or compounds.
2) in liquids, a solution that contains enough of a dissolved solid, liquid, or gas so that no more will dissolve into the solution at a given temperature and pressure.

Scabbing Breaking off of fragments from the inside wall of hard material due to impact or explosion of a projectile on the outside. *See Spall.*

Scale the precipitate that forms on surfaces in contact with water as the results of a physical or chemical change, often due to the presence of calcium carbonate (CaCO3) or magnesium carbonate (MgCO3).

Scaled Distance A factor relating similar blast effects from various size charges of the same explosive at various distances. Scaled distance referring to blasting effects is obtained by dividing the distance of concern by a fractional power of the weight of the explosive materials.

Scaling Law A formula which permits calculating some explosive effect based on data obtained from a similar but different size article.

SCID (Small Column Insulated Delay) Slow burning pyrotechnic core contained in a flexible metallic sheath used to produce delay trains.

Scratch mix A coarsely sieved mixture of Potassium Nitrate, Charcoal and Sulphur primarily used as a prime for stars.

Screecher Physically a whistle with a hole through it, producing a much more "rasping" sound. In a screecher the instability arising from the oscillations of burning interfere with each other almost to the point of causing the resulting firework to detonate.

Screening Smoke A screening smoke is a cloud that consists of small particles of solids, liquids, or both, dispersed and suspended in air. Chemical agent which, when burned, hydrolysed or atomised produces an obscuring smoke. Used to deny observation and reduce effectiveness of aimed fire.

Second (sec or s), Fundamental unit of time in all systems of measurement. In practical terms, the second is 1/60 of a minute and 1/3,600 of an hour. Since 1967 it has been calculated by atomic standards to be 9,192,631,770 periods of vibration of the radiation emitted at a specific wavelength by a cesium-133 atom.

Secondary Explosive A high explosive which is relatively insensitive to heat and shock, usually initiated by a primary explosive or by an exploding bridgewire.

Secondary Fragmentation Fragments produced by an explosive device that are made up of the target materials or other materials other than those directly resulting from the device itself.

Sedimentation the deposition of suspended matter carried by water, wastewater, or other liquids, by gravity. It is usually accomplished by reducing the velocity of the liquid below the point at which it can transport the suspended material. Also called settling.

Seismograph An instrument, useful in monitoring blasting operations, that records ground vibration. Particle velocity, displacement, or acceleration is generally measured and recorded in three mutually perpendicular directions.

Semiconductive Hose A hose with an electrical resistance high enough to limit flow of stray electric currents to safe levels, yet not so high as to prevent drainage of static electric charges to ground. Hose of not more than 2 megohms resistance over this entire length and of not less than 5,000 ohms per foot meets the requirement.

Semiconductor a solid material (Solid State Physics) whose electrical conductivity at room temperature lies between that of a conductor and that of an insulator (Conduction; Insulation). At high temperatures its conductivity approaches that of a metal, and at low temperatures it acts as an insulator. In a semiconductor there is a limited movement of electrons, depending upon the crystal structure of the material used. Incorporation of certain impurities in a semiconductor enhances its conductive properties. The impurities either add free electrons or create holes (electron deficiencies) in the crystal structures of the host substances by attracting electrons. Thus there are two semiconductor types: the n-type (negative), in which the current carriers (electrons) are negative, and the p-type (positive), in which the positively charged holes move and carry the current. Compounds such as indium antimonide, gallium arsenide, and aluminum phosphide are semiconductors. Semiconductors are used in electronic devices such as computers, Photoelectric Cells, Rectifiers, and Transistors.

Semtex Trade name of a plastic explosive (Plastic Bonded Explosives) from the Czechoslovakian firm Synthesia, Pardubice-Semtin. Semtex consists of Pentaerythritol Tetranitrate and styrene-butadiene copolymer as a plasticizer. Detonation rate: 5000 m/s; Oxygen balance: -44.0%; Critical diameter: 15 mm .

Senko hanabi A delicate pyrotechnic sparking effect, commonly produced in Japan, produced from the burning of a sulphur-rich blackpowder composition. When burned, the droplets of molten composition that form react further with air to produce attractive branching sparks.

Sensitiveness A measure of an explosive's cartridge-to-cartridge propagating ability under certain test conditions. It is expressed as the distance through air at which a primed half-cartridge (donor) will detonate an un-primed half-cartridge (receptor).

Sensitivity A physical characteristic of an explosive material classifying its ability to be initiated upon receiving an external impulse such as impact, shock, flame, friction, or other influences that can cause explosive decomposition. The ease of ignition of a firework composition. Highly sensitive compositions (e.g flash powder) require extremely

careful handling.

Separated Ammunition is characterized by the arrangement of the propelling charge and the projectile for loading into the gun. The propelling charge, contained in a primed cartridge case that is sealed with a closing plug and the projectile are loaded into the gun in one operation. Separated ammunition is used when the ammunition is too large to handle as fixed ammunition.

Separate-Loading Ammunition in which the projectile, propelling charge and primer are not held together in a shell case, as in fixed ammunition, but are loaded into a gun separately. No cartridge case is utilized in this type of ammunition.

Separating Burst Method of ejecting the contents of a projectile by means of a charge of propellant that breaks the projectile into two approximately equal parts, along a specially designed circumferential shear joint.

Separation Distances Minimum recommended distances from explosive materials accumulations to certain specific locations.

Sequence Usually refers to the pattern of firing of a section of a display. For instance a sequence could comprise 10 x 3" gold shells followed by 10 x 4" gold shells followed by 5 x 5" gold shells.

Sequencer An electrical firing system used to send regular electric pulses to fire a number of fireworks in a very accurately controlled manner.

Series Blasting Circuit An electric blasting circuit that provides one continuous path for the current through all caps in the circuit.

Series circuit The preferred method of linking multiple electric igniters. Series circuits are arranged so that the current runs through each ignitor in a sequential way. Series circuits are much easier to test for continuity and correct wiring than parallel circuits.

Series in Parallel Blasting Circuit An electric blasting circuit in which the ends of two or more series of electric detonators are connected across the firing line directly or through buswire.

Serpent Usually a small tube filled with composition and possible a report charge, that is fired en masse from shells, mines, or rarely Roman candles. The serpents fly about in a random fashion prior to bursting with a report or stars.

Set piece A generic term for a ground firework but usually distinguished from Lancework. The set piece may be static or revolving and is made up from gerbs and/or noise and colour units.

Shaped Charge An explosive charge with a lined cavity specifically designed to produce a high velocity cutting or piercing jet of liner material. See Mohaupt Effect.

Sheet Explosive Known by many trade names, such as Metabel, Deta sheet, Series 1000 - PETN sheet explosive, and Series 2000 - RDX sheet explosive. These plastic bonded explosives have a very high brisance and detonating velocity. Sheet explosive is in most cases the explosive of choice for the tactical loading of the HYDRO CUT Entry and Gun Port Frames. Sheet explosive is supplied in rolls which are a standard 10" wide. Depending on the thickness of the sheet explosive it is supplied as two X 10 pound rolls per box, or two X 20 pound rolls per box.

Shelf Life The length of time of storage during which an explosive material retains adequate performance characteristics. The storage time, during which an explosive item remains serviceable.

Shell delay A more precise term than delay fuse, this refers to the internal delay within a shell to permit it to ascent to its desired height before igniting the bursting charge. Shell delays are commonly made from composition pressed into a card tube (for cylinder shells, especially those with plastic moulded cases) and variations of Bickford fuse.

Shell Hollow projectile filled with explosive, or chemical or other material as opposed to shot, which is a solid projectile.

Shell of shells An aerial display shell that contains internal shells that are ignited when the main shell bursts, and subsequently produce secondary bursts.

Shell The most spectacular of fireworks comprising a lifting charge (to propel the shell into the air) and a bursting charge to eject stars or subassemblies in the air after a predetermined delay. Shells are fired from mortars.

Shellac Orange-yellow powdered organic resin. Considered a superior fuel for use in coloured flame compositions. Solvents are alcohol and acetone.

Shield A safeguard securely braced and of a strength proven sufficient to withstand the effects of the maximum credible incident involving the item being handled.

Shock Wave Rapid expansion of hot gases resulting from detonation of an explosive charge. A shock wave is a wave formed of a zone of extremely high pressure within a fluid, especially one such as the atmosphere, that propagates through the fluid at supersonic speed, i.e., faster than the speed of Sound. Shock waves are caused by the sudden, violent disturbance of a fluid, such as that created by a powerful explosion or by the supersonic flow of a fluid over a solid object.

Short circuit Usually the accidental completion of an electrical circuit which causes the current not to flow through the electric igniters and thus leads to line failure. Short circuits can usually be discovered readily in series circuits by electrical testing of the circuit with an ohmmeter.

Short-Delay Blasting The practice of detonating blastholes in successive intervals where the time difference between any two successive detonations is measured in milliseconds.

Shot Firer That qualified person in charge of and responsible for the loading and firing of a blast (Blaster).

Shot - Mil. 1) A solid projectile for cannon, without a bursting charge.

2) Pellets; small balls, or slugs in shotgun shells, also some other types of ammunition.

Shot - Fwk. Usually refers to the single functioning of, say, a cake. Roman candles are often referred to as "8 shots".

Shrapnel Artillery projectile which contains small lead balls that are propelled by a powder charge in the base, set off by a time fuse. Shrapnel has been replaced almost entirely by high-explosive shells. Wounds called shrapnel wounds usually are due to shell fragments rather than to shrapnel.

Shrinkage Contraction of propellant grain from wet (green) dimensions (as it comes from the graining dye) to the dry dimensions after solvent extraction and evaporation.

SI System Of Measurement SI, which is the abbreviation of the French word "Systeme Internationale d'Unites", is the accepted abbreviation for the International Metric System, which has several base units.

Siatene shell An aerial shells comprising several maroons that burst in a ring pattern at the same time.

Sieves

Signal A pyrotechnic item designed to produce a sign (illumination, smoke or sound) to provide identification, location, warning, etc.

Signalling Smoke Any type of smoke, but usually coloured smoke from a hand or rifle grenade, or from a message.

Signs-Explosive (Placards) Signs, called placards, placed on vehicles transporting explosives denoting the character of the cargo, or signs placed near storage areas as a warning to unauthorized personnel.

Silica A compound of silicon such as quartz sand.

Silicon Dioxide [SiO2] Also known as Cab-o-sil and Aero-sil, have a particle size of less of than 20Ý. Used as a free-flowing aid, also used as an aid in preventing electrostatic charges in powdered compositions and as a thickening product. Its has also be used as a coating on certain metal powders including iron and aluminium.

Silicon [Si] Dark grey powder used to increase the effectiveness of ignition or priming compositions by raising the flame temperature and producing molten glass droplets, in the form of a hot slag. Generally used in compositions with potassium nitrate and gunpowder.

Silicone A modern type of plastic.

Silver Chloride Cell A special battery of relatively low current output used in a blasting galvanometer.

Simulated Military Gases Simulated agents are essentially mild non-toxic harassing agents (substitutes for the real agent) designed specifically for training purposes.

Simulator An item which simulates a hazardous item for training purposes, also a type of test instrument.
Single-Base Propellant whose principal active ingredient is nitrocellulose.

Slurry An explosive material containing substantial portions of a liquid, oxidizers, and fuel, plus a thickener.

AN Slurry An aqueous explosive material solution of AN sensitised with a combustible fuel (and thickened with a gelling agent at the point of charging).

Small Arms Ammunition Any shotgun, rifle, pistol, or revolver cartridge, and cartridges for propellant-actuated power devices and industrial guns.

Small Arms Ammunition Primers Are small percussion-sensitive explosive charges, encased in a cup, used to ignite propellant powder.

SMDC (Shielded Mild Detonating Cord) MDF contained in a small (.180" diameter) steel tubing. Sometimes referred to as hardline CDF.

Smoke An air suspension of particles usually from incomplete combustion of a composition. Can also include the airborne suspension of solid particles from the products of detonation or deflagration.

Smoke Dye, Blue (phthalocyanine blue). Light blue powder used typically with potassium chlorate and lactose to produce blue coloured smoke, often used in daytime aerial shells; also used as a burn rate enhancer in rockets.

Smoke Shell Any projectile containing a smoke-producing chemical agent that is released on impact or burst. Also called smoke projectile. Smoke may be white or coloured.

Smokeless powder A pyrotechnic mixture containing nitrocellulose and nitroglycerine so called because, unlike blackpowder, it does not produce much smoke on burning. In this way it found favour as a propellant in small arms devices, although its use in fireworks is rare.

Smokeless Propellant (Smokeless Powder) commonly called smokeless powder in the trade, used in small-arms ammunition, cannon, rockets, propellant-actuated power devices, etc. Is safer to handle and store, as it produces no "fouling" or corrosion to the firearm, which is a characteristic of gunpowder. However, gas pressures produced by smokeless powders are far greater than gunpowder, and requires a considerably stronger firearm.

Sodium Benzoate [NaC7H5O2] white powder used as a fuel in making whistle composition in rockets and in shell burst charges.

Sodium Bicarbonate Or sodium hydrogen carbonate, chemical compound **[NaHCO3]**, a white crystalline or granular powder, commonly known as bicarbonate of soda or baking soda. It is soluble in water and very slightly soluble in alcohol. Because it evolves carbon dioxide gas when heated above 50ÝC (122Ý F), it is used in baking powder. It is sometimes used medically to correct excess stomach acidity. Used also as a glitter effect enhancer, a delay agent, and sometimes as a yellow colour agent.

Sodium Carbonate A chemical compound [Na2CO3] soluble in water and very slightly soluble in alcohol. Pure sodium carbonate is a white, odourless powder that absorbs moisture from the air and forms a strongly alkaline water solution. One of the most basic industrial chemicals, it is usually produced by the Solvay process. The chief uses of sodium carbonate are in glassmaking and the production of chemicals.

Sodium Chloride [NaCl], common salt. It is a chemical compound containing equal numbers of positively charged sodium and negatively charged chlorine Ions. The colourless-to-white crystals have no odour but a characteristic taste. When dissolved in water, the ions move about freely and conduct electricity (Electrolysis). Salt is essential in the diet of humans and animals, and is a part of blood, sweat, and tears. Salt is widely used for the seasoning, curing, and preserving of foods. Its major use is in the production of Chlorine, Sodium, and Sodium Hydroxide. Salt makes up nearly 80% of the dissolved material in seawater and is also widely distributed in solid deposits. Manufacture and use of salt is one of the oldest chemical industries.

Sodium [Na], metallic element, discovered in 1807 by Sir Humphrey Davy; its compounds have been known since antiquity. A silver-white, very reactive Alkali Metal, it must be stored out of contact with air and water. The metal is used in arc-lamp lighting, as a heat-transfer liquid in nuclear reactors, and in manufacture of tetraethyl lead.

Widely used compounds include Sodium Chloride (common salt), Sodium Bicarbonate (baking soda), Sodium Carbonate (soda ash), hydroxide (lye), nitrate, phosphates, and Borax. Soap is made with sodium hydroxide. Sodium compounds are widely distributed in rocks, soil, oceans, salt lakes, mineral waters, and salt deposits, and are found in the tissues of plants and animals. Sodium is an essential element of the diet.

Sodium Nitrate [NaNO3] White powder used as a yellow colour agent and as an oxidizer.

Sodium Oxalate [Na2C2O4] White powder, used as a yellow colour agent and as an glitter effect enhancer (delay agent).

Sodium Salicylate [NaC7H5O3] White powder used as a fuel in whistle composition. Is liable to absorb moisture from the air and thereby deteriorate. Chemically related to both asprin and methol.

Sodium Silicate (waterglass) **[Na2Si3O7]** A clear solution dissolved in water used in pyrotechnic adhesives, particularly in rolling cup sets in sawdust and for making paper tubes fire resistant. Thin with water.

Sodium Sulphate [Na2SO4] White powder used as a high temperature oxidizer in some yellow strobe compositions.

Sodium Tetraborate Decahydrate Borax or chemical compound **[Na2B4O7.10H2O]** occurring as a colourless, crystalline salt or a white powder. Borax is used as an antiseptic, cleansing agent, water softener, corrosion inhibitor in anti freeze, and flux for silver soldering, and in the manufacture of fertilizers, Pyrex glass, and pharmaceuticals.

Sofar Bomb A sound producing bomb designed to detonate at a given depth under water.

Solar Energy Any form of Energy radiated by the Sun, including light, radio waves, and X rays. Solar energy is needed by green plants for the process of Photosynthesis, which is the ultimate source of all food. The energy in fossil fuels (e.g., coal and petroleum) and other organic fuels (e.g., wood) is derived from solar energy. Difficulties with these fuels have led to the invention of devices that directly convert solar energy into usable forms of energy, such as electricity. Solar batteries, which operate on the principle that light falling on photosensitive substances causes a flow of electricity, play an important part in astronautics but are presently too expensive to be in common use on the earth (Photovoltaic Cell). Thermoelectric generators convert the heat generated by solar energy directly into electricity. Heat from the sun is used in air-drying a variety of materials and in producing salt by the evaporation of sea water (Desalination). Experimental solar heating systems can supply heat and hot water for domestic use; heat collected in special plates on the roof of a house is stored in rocks or water held in a large container. Such systems, however, usually require a conventional heater to supplement them. Solar stoves, which focus the sun's heat directly, are employed in regions where there is perennial sunlight.

Solar System The Sun and the family of Planets, natural Satellites, Asteroids, Meteors, and Comets; in order of increasing distance from the sun, they are MERCURY, VENUS, EARTH, MARS, JUPITER, SATURN, URANUS, NEPTUNE, and PLUTO. All the planets orbit the sun in approximately the same plane (that of the ECLIPTIC) and move in the same direction (from west to east). Current theories suggest that the solar system was formed from a NEBULA consisting of a dense nucleus, or protosun, surrounded by a thin shell of a gaseous matter extending to the present edges of the solar system. Because of gravitational instabilities, the nebula eventually broke up into whirlpools of gas, called protoplanets, within the rotating mass. In time the protoplanets condensed and accreted to form the planets.

Solar Time defined by the position of the sun. The observer's local solar time is 0 hr (noon) when the centre of the sun is on the observer's meridian. The solar day is the time it takes for the sun to return to the same meridian in the sky. The length of the solar day varies throughout the year because the earth moves with varying speed in its orbit and because the equatorial plane is inclined to the orbital plane. It is thus more convenient to define time in terms of the mean solar time, or average of local solar time; hence every mean solar day is of equal length. The equation of time is the difference between the local solar time and the mean solar time at a given location. Civil time is mean solar time plus 12 hr; the civil day begins at midnight, whereas the mean solar day begins at noon. Greenwich mean time (GMT) is the local civil time at the former site of the Royal Observatory in Greenwich, England, which is located on the Prime Meridian (0Ý longitude). Standard time is the civil time within one of the 24 time zones into which the earth's surface is divided. Within a zone all locations keep the same time, namely, the mean solar time of the central meridian (except when Daylight Saving Time is in effect). Zone times generally differ by a whole number of hours from GMT.

Solar Wind A stream of ionised hydrogen and helium that radiates outward from the sun, carrying away about 1 million tons of gas per sec. Near the earth the solar wind normally has a velocity of 450 mi/sec (700 km/sec). The wind is believed to extend to between 100 and 200 astronomical units from the sun. Comet tails always point away from the sun because of the pressure exerted by the solar wind. The interaction of the solar wind with the earth's magnetic field is also responsible in part for such phenomena as the auroras and geomagnetic storms.

Solder an alloy of lead/tin used for making permanent electrical connections between parts and wire.

Solid Propellant Specifically, a rocket propellant in solid form, usually containing both fuel and oxidizer combined or mixed and formed into a monolithic (not powdered or granulated) grain.

Solute the substance that is dissolved to form a solution.

Solution a liquid (solvent) that contains a dissolved substance (solute).

Solvent a liquid used to dissolve another substance.

Sonic boom A sonic boom is a Shock Wave produced by an object moving through the air at supersonic speed, i.e., faster than the speed of sound. An object, such as an airplane, moving through the air generates sound. When the speed of the object exceeds the speed of sound, the object forces the sound ahead of itself faster than the speed at which the sound would ordinarily travel. The piled-up sound takes the form of a violent shock wave propagating behind the object.

Sorbitol [C6H14O6] White powder used as a fuel in some rocket compositions.

Sound is pressure Waves that propagate through air or other media. Sounds are generally audible to the human ear if their frequency lies between 20 and 20,000 vibrations per second. Sound waves with frequencies below the audible range are called subsonic, and those with frequencies higher than the audible range are called ultrasonic (Ultrasonics). When a body, such as a violin string, vibrates, or moves back and forth, its movement in one direction pushes the molecules of the air before it, crowding them together. When it moves back again past its original position and on to the other side, it leaves behind it a nearly empty space. The body thus causes alternately in a given space a crowding together of the air molecules (a condensation) and a thinning out of the molecules (a rarefaction). The condensation and rarefaction make up a sound wave; such a wave is called longitudinal, or compressional, because the vibratory motion is forward

and backward along the direction that the wave is following. Because such a wave consists of a disturbance of particles of a material medium, sound waves cannot travel through a vacuum. The velocity of sound in air at 32ÝF (0ÝC) is 1,089 ft/sec (331.9 m/sec), but at 68ÝF (20ÝC) it is increased to about 1,130 ft/sec (344.4 m/sec). Sound travels more slowly in gases than in liquids, and more slowly in liquids than in solids. The pitch of a sound depends upon the frequency of vibration; the higher the frequency, the higher the pitch. Loudness, or intensity of sound, is measured in units called Decibels.

Sound Speed A materials sound speed is the rate at which sound is conducted through that particular medium. A materials sound speed is also effected by the temperature the particular material is at. For example at standard temperature and standard pressure (STP) the velocity of sound in air is 340 m/s, (331 m/s at 0Ý C). The density of air at STP is 1.39 kg/m3. In air or other gases, the velocity of sound increases proportionally with the square root of the absolute temperature; the velocity increase is approximately 2% for each 10Ý C temperature increase. Usually, the temperature decreases with altitude - an average of the gradient is 0.6Ý C per 100 meters.

Space-Time the central concept in the theory of Relativity that replaces the earlier concepts of space and time as separate absolute entities. In space-time, events in the universe are described in terms of a four-dimensional continuum, in which each observer locates an event by three space-like coordinates and a time-like coordinate. The choice of the last is not unique; hence, time is not absolute but is relative to the observer.

Spall Fragments broken from either surface of a barrier (for example, fragments broken from an armour plate as the result of penetration, impact of a projectile, or detonation against the plate).

Spark The typical effect caused by incandescent particles ejected from the burning surface of a composition.

Sparkler Usually a wire coated with pyrotechnic composition that gives off small sparks when burnt. Sparklers, although considered safe, are the cause of the greatest number of hospitalised accidents in the UK each season.

Special Fireworks are Class B explosives as defined by the U.S. Department of Transportation.

Specific Density Mass per unit volume of a homogeneous material. In interior ballistics, it is usually distinguished from loading density and gravimetric density.

Specific Energy The specific energy of an explosive is defined as its working performance per kg, calculated theoretically from the general equation of state for gases: f = pV = nRT where p is the pressure, V is the volume, n is the number of moles of the explosion gases per kg (® also Volume of Detonation gases), R is the ideal gas constant, and T is the absolute temperature of the explosion. If we put the volume equal to unity, i.e., if the loading density is unity, the specific energy becomes f = p i.e., is equal to the pressure which would be exerted by the compressed explosion gases in their confinement, if the latter were indestructible. This is why the term "specific pressure" is also frequently used, and why the magnitude f is often quoted in atmospheres. Nevertheless, strictly speaking, [is an energy value and for this reason is reported in meter-tons per kg. The value of twill have this dimension if R is taken as 0.8479 + 10-3mt + K + mol. In accordance with recent standardization regulations, the energy data are also reported in joules.

Specific Gravity The ratio of the Weight of any volume of substance to the weight of an equal volume of pure water, at a standard temperature.

Specific Heat is the ratio of the Heat Capacity of a substance, to the heat capacity of a reference substance, usually water. Because the heat capacity of water is 1 BTU/Lb per degree Fahrenheit or 1 cal/gram per degree Celsius, the specific heat of a substance relative to water will be numerically equal to its heat capacity.

Specific Impulse The thrust in pounds developed by burning one pound of a particular propellant in one second.

Spectrum The arrangement or display of Light or other forms of Electromagnetic Radiation separated according to wavelength, frequency, energy, or some other property. Dispersion, the separation of visible light into a spectrum, may be accomplished by means of a prism or a Diffraction grating. Each different wavelength or frequency of visible light corresponds to a different colour, so that the spectrum appears as a band of colours ranging from violet at the short-wave length (high-frequency) end of the spectrum through indigo, blue, green, yellow, and orange, to red at the long-wavelength (low-frequency) end of the spectrum. A continuous spectrum containing all colours is produced by all incandescent solids and liquids and by gases under high pressure. A low-pressure gas made incandescent by heat or by an electric discharge emits a spectrum of bright emission lines. A dark-line absorption spectrum is produced by white light passing through a cool gas and consists of a continuous spectrum with superimposed dark lines; each line corresponds to a frequency where a bright line would appear if the gas were incandescent. The absorption lines correspond to transitions of electrons from a lower energy level to a higher energy level when a Photon is absorbed by the atom, and the emission lines correspond to transitions from a higher to a lower energy level in the atom, accompanied by the emission of a photon. The frequency of each emission or absorption line is proportional to the difference in energy between the two energy levels involved (Quantum Theory). Both absorption and line spectra are useful in chemical analysis, because they reveal the presence of particular elements.

Spider shell An aerial shell having a small number of relatively large stars producing an asymmetric break. Spider shells having 24 large comets are sometimes called Octopus shells.

Spiking horse The device used to facilitate the spiking, or stringing, of shells.

Spiking *see stringing*.

Spin Angular velocity about the axis of the projectile.

Spin Stabilization Method of stabilizing a projectile during flight by causing it to rotate about its own longitudinal axis.

Spin-Decelerating Moment A couple about the axis of the projectile which diminishes spin.

Spiral wound tube A paper tube wound from several narrow paper strips at an angle. Roman candles made with spiral tubes are prone to failure if fire can be transferred by loose composition trapped in the spiral winding.

Splitting comet A comet in which there is an internal charge (usually of flash powder) which when ignited splits the comet into several pieces. The effect is of a comet that travels for some period and then fragments. Splitting comet stars are typically found in shells, mines, and especially Roman candles. *see Crossette*

Spolette A shell or Roman candle delay fuse usually made from pressing blackpowder into a small bore tube.

Spray Fragments of a bursting shell. The nose, side and base sprays are the fragments thrown forward, sideways and rearward, respectively.

Squib Igniter *see Electric igniter*

Squib A firing device that burns with a flash and is used for igniting black powder or pellet powder.

Squib Switch (Explosive Switch) An electric switch operated by a squib or pressure cartridge.

Stability Test Accelerated test to determine the suitability of an explosive material for long-term storage under a variety of environmental conditions.

Stability The ability of an explosive material to retain its original properties without degradation (or to retain chemical and physical properties specified by the manufacturer) when exposed to various environmental conditions over a period of time.

Stabilizer Material added to propellant colloid to inhibit, or reduce, decomposition in storage.

Stacked Charge Powder charge in which the powder grains lie end to end within the powder bag.

Staging Area The area directly outside of the target area, the final location where the assault element will prepare to enter the target area.

Stand Off The distance between a shaped charge liner and the target material.

Standard (or standardized solution) a solution containing a known, precise concentration of an element or chemical compound, often used to calibrate analytical chemistry measurement devices.

Standard Atmosphere Values of air temperature, pressure and density vs. altitude based on average conditions and arbitrarily assumed as standard for computations. Various standards are in current use.

Standard Deviation (Sigma) The square root of the sum of the squared deviations from the mean. For a given sample, this must be divided by the sample size in order to correct for bias and be a proper estimate of the true population. A measure of the variability or dispersion of a number of observations.

Standard Trajectory Calculated path that a projectile will follow under given conditions of weather, position and material, including the particular fuze, projectile and propelling charge that are used. Firing tables are based on standard trajectories.

Star (astrological) Star, hot, incandescent sphere of gas (usually more than 90% hydrogen) that is held together by its own gravitation and emits light and other forms of electromagnetic radiation whose ultimate source is nuclear energy. The universe contains billions of galaxies, and each galaxy contains billions of stars, which are frequently bunched together in star clusters of as many as 100,000. The stars visible to the unaided eye are all in our own galaxy, the Milky Way. The visible stars are divided into six classes according to their apparent Magnitude. Stars differ widely in mass, size, temperature, age , and luminosity. About 90% of all stars have masses between one tenth and 50 times that of the sun. The most luminous stars (excluding supernovas) are about a million times more powerful than the sun, while the least luminous are only a hundredth as powerful. Variable stars fluctuate in luminosity. Red giants, the largest stars, are

hundreds of times greater in size than the sun. At the opposite extreme, white dwarfs are no larger than the earth, and neutron stars are only a few kilometres in radius. The central region, or core, has a temperature of millions of degrees. At this temperature nuclear energy is released by the fusion of hydrogen to form helium. By the time nuclear energy reaches the surface of the star, it has been largely converted into visible light with a spectrum characteristic of a very hot body. The theory of stellar evolution states that a star must change as it consumes its hydrogen in the nuclear reactions that power it. When all its nuclear fuel is exhausted, the star dies, possibly in a supernova explosion.

Star (pyrotechnic) Pyrotechnic signal that burns as a single light.

Star Gauge Instrument for measuring the diameter of the bore of a gun.

Star Grain A solid propellant grain with an internal star-shaped cross section.

Star Mine A mine in which the projection of coloured stars is the principle effect.

Star Pellets of composition (usually cylinders, cubes or spheres) used in mines, shells, roman candles, rockets and occasionally gerbs.

Starch [(C6H10O5)n] a white hydroscopic powder, dissolves in hot water to form a thick adhesive solution. Sometimes used in the manufacture of quickmatch and stars. Can be used to reduce the burning rate of various compositions. Can be hydrolysed to dextrine and finally to D-glucose.

Stark Rubber Natural rubber which has crystallized over several years by storage at low temperature.

Starpol [C6H10O5] Light yellow powder. A starch based, water soluble binder with more adhesiveness than dextrin, you can also use less of it than dextrin. Less hygroscopic than dextrin, it reduces water absorption problems in some formulas, such as those containing strontium nitrate.

Starting Mix An easily ignited mixture that transmits flame from an initiating device to a less readily ignitable composition.

States Of Matter The forms of matter differing in several properties because of differences in the motions of and the forces between the molecules (or atoms or ions) of which they are composed. There are three common states of matter: solid, liquid, and gas. The molecules of a solid are limited to vibrations about a fixed position, giving a solid both a definite volume and a definite shape. When heat is applied to a solid, its molecules begin to vibrate more rapidly until, at a temperature called the melting point, they break out of their fixed positions and the solid becomes a liquid. Because the molecules of a liquid are free to move throughout the liquid but are held from escaping by intermolecular forces (Adhesion and Cohesion), a liquid has a definite volume but no definite shape. As more heat is added to the liquid, some molecules near the surface gain enough energy to evaporate, or break away completely from the liquid, and change to a gaseous state. Finally, at a temperature called the BOILING POINT, molecules throughout the liquid become energetic enough to escape, forming bubbles of vapour that rise to the surface; the liquid thus changes completely to a gas. Because its molecules are free to move in every possible way, a gas has neither a definite shape nor a definite volume but expands to fill any container in which it is placed. The reverse processes of melting and boiling are, respectively, freezing and condensation.

Static Electricity Electric charge at rest on a person or object. It is most often produced by the contact and separation of dissimilar insulating materials. Can pose a serious problem with certain pyrotechnic compositions.

Static Entry A description given to a type of entry where a team member has access to the target area, but is not moving into or around the target area, an example would be a gun port breach point.

Statics is a branch of Mechanics concerned with the maintenance of equilibrium in bodies by the interaction of Forces upon them. In a state of equilibrium the resultant of all outside forces acting on a body is zero, thus keeping the body at rest.

Statistical Method A technique used to obtain, analyse and present numerical data.

Statistics The science which deals with the collection, classification and use of numerical data relating to a given subject.

Steady State Velocity The characteristic velocity at which a specific explosive at a given charge diameter will detonate.

Steam Water in the vapour state, formed when specific latent heat of vaporisation is supplied to water at boiling point. The specific latent heat varies with the pressure of formation, being @ 2257 kJ kg-1 at atmospheric pressure.

Stearic Acid (n-octadecanoic acid) **[C18H36O3]** A mono-basic fatty acid; melting point 69ÝC, boiling point 287ÝC. Used as a phlegmatizing agent, a low reactivity (accessory) fuel and a pressing aid.

Stearin [C21H42O4] A term for the glyceryl ester of stearic acid. Used as an aid in producing metal powders and sometimes as a fuel. The name is sometimes also applied to a mixture of stearic acid and palmitic acid.

Steel mortar A mortar made from steel tube, with a steel plate welded to the base. Steel mortars are not recommended by Big Bang Fireworks due to the potential problem which has occurred because of the fragmentation, should a shell burst within the tube. Some operators still use shells (particularly cylinder shells) in steel mortars, if they are to be used, it is recommended that tubes are made from suitable steel plate and welded along it's seam, and NEVER USE CAST IRON TUBES. The use of HDPE tubes and reinforced fibre-glass tubes are likely to reduce the use of steel mortars in the future.

Steel powder [Fe + C] Grey powder, produces medium-fine, yellow-orange sparks. Used to manufacture sparklers.

Stemming A suitable inert or incombustible device used to confine or separate explosives in a drill hole, or to cover explosives in mudcapping.

Stoichiometric Relating to components involved in a burning process which are present in exactly the quantities needed for reaction, without an excess of any component.

Storage The holding of fireworks or explosives prior to their use. In most countries storage above a certain quantity requires a licence, usually in specially designed structures called magazines.

STP (Of Gases) At standard temperature and pressure.

Stray Current A flow of electricity outside an insulated conductor system.

Strength of materials the capacity of materials to withstand stress (the internal force exerted by one part of an elastic body upon an adjoining part) and strain (the deformation or change in dimension occasioned by stress). When a body is subjected to a pull, it is said to be under tension, or tensional stress; when it is compressed, it is under

compression, or compressive stress. Shear, or shearing stress, results when a force tends to make part of a body slide past the other part. Torsion, or torsional stress, occurs when external forces tend to twist a body around an axis. The elastic limit is the maximum stress that a material can sustain and still return to its original form. The ratio of tensile stress to strain for a given material is called its Young's modulus. Hooke's law states that, within the elastic limit, strain is proportional to stress.

Strength The explosive strength of unit weight (or volume) of a high explosive when compared with that of Blasting Gelatine in a ballistic mortar. Although compared with Blasting Gelatine it is sometimes designated in percentage of nitroglycerine (%NG). This latter designation is not a true measure of its strength.

Striker Part of the firing mechanism of a gun, mine, mortar, etc., that hits the primer, hammer or firing pin of a gun.

Striking Velocity Speed of a projectile at the point of impact.

Stringing *See Spiking*. The process of winding a strong string, around the outer surface of a shell to produce a more regular bursting pattern.

Strobe The effect of a strobe is the regular pulsing "on-off-on-off" of light as a firework composition burns, There are several proposed explanations of this effect. Strobe effects are most often seen in ground fireworks (strobe pots) or as stars in an aerial shell or rocket.

Strontium [Sr] Silvery white metal, found naturally in celestine and strontianite; melting point 800ÝC and boiling point 1300ÝC. Compounds give crimson red colour to flames. Has 13 isotopes.

Strontium Carbonate [SrCO3] White or pale tan powder, 325 mesh. The most commonly used red flame colouring agent.

Strontium Chloride [SrCl2] White granules, easily milled into fine powder. Red colour agent for stars, campfire logs, etc.

Strontium Chromate [SrCrO4] Bright yellow powder used as an oxidizer, possibly as a rocket fuel catalyst.

Strontium Nitrate [Sr(NO3)2] White powder used as a red colouring agent oxidizer often with metal fuels in stars, flares,

Strontium Sulphate [SrSO4] White powder used as a high temperature oxidizer in some red strobe compositions.

Sublimation The vapourization of a solid without the intermediate formation of a liquid.

Subsonic Less than the speed of sound i.e. Mach 1.

Substantial Dividing Wall A structure designed to resist the effects of accidental explosions or to prevent propagation of detonation by blast or fragments.

Sucrose [C12H22O11] White monoclinic crystals; melting point 160ÝC. Hydrolyses to glucose and fructose.

Sugar Common term for sucrose, refined sugar or cane-sugar; @ 130g of sugar can be extracted from 1kg of sugar beet.

Sulfur American spelling of sulphur.

Sulphur [S] non-metallic element, known to antiquity as the biblical brimstone and recognized as an element by Antoine Lavoisier in 1777. Solid sulphur is yellow, brittle, odourless, tasteless, and insoluble in water. Sulphur is widely distributed in minerals and ores, some volcanic regions, and large underground deposits, and often occurs with coal, natural gas, and petroleum. It is found in most proteins and protoplasm of plants and animals. Sulphur is used in Gunpowder, matches, Rubber vulcanisation, insecticides, and the treatment of certain skin diseases., Sulphuric Acid is its most important compound. Sometimes buffered with @ 1% magnesium carbonate if slightly acidic.

Sulphur flour (not the same as "flowers"). Yellow powder. Used as a fuel, usually in compositions with nitrate oxidizers.

Sun intensely hot, self-luminous body of gases (mainly hydrogen and helium) at the centre of the Solar System. The sun is a medium-size main-sequence Star. Its mean distance from the earth is defined as one Astronomical Unit. The sun is c.865,400 mi (1,392,000 km) in diameter; its volume is about 1,300,000 times, and its mass 332,000 times, that of the earth. At its centre, the sun has a density over 100 times that of water, a pressure of over 1 billion atmospheres, and a temperature of about 15,000,000ÝK. This temperature is high enough for the occurrence of nuclear reactions, which are assumed to be the source of the sun's energy. Hans Bethe proposed a cycle of nuclear reactions known as the carbon cycle, in which carbon acts much as a catalyst; while hydrogen is transformed, by a series of reactions into helium and large amounts of high-energy gamma radiation are released. The so-called proton-proton process is now thought to be a more important energy source: the collision of two protons ends with the production of helium atoms and the release throughout of gamma radiation. The bright surface of the sun is called the photosphere; its temperature is about 6000ÝK. During an Eclipse of the sun, the chromosphere (a layer of rarified gases above the photosphere) and the corona (a luminous envelope of extremely fine particles surrounding the sun, outside the chromosphere) are observed.

Superconductivity the total disappearance of electrical resistance in a wire or circuit. Discovered in 1911, superconductivity only appears in a specific material below a critical temperature. The major problems confronting the possible applications of superconductivity were the extremely low temperatures initially required (only a few degrees above absolute zero) and the fact that a strong magnetic field could destroy it. Much research has been done in recent years in the field of "high-temperature" superconductivity. Newer composites permit the absence of electrical resistance at temperatures near 125Ý K (-243Ý F).

Superfluidity The capability of liquid helium cooled below a temperature of 2.19ÝK (the lambda point) to flow freely, even upward, with no measurable friction and viscosity. Superfluid helium flows easily through capillary tubes (Capillarity) that resist the flow of ordinary fluids, and a Dewar Flask filled with superfluid helium from a larger container will empty itself back into the original container because the liquid helium flows spontaneously in an invisible film over the surface of the flask.

Superglue Popular name for cyanoacrylate adhesive, supplied as fluid monomer or prepolymer, which polymerizes when in contact with surfaces.

Superquick Fuse that functions immediately upon impact of the missile with the target. Action of this type of fuse is the quickest possible; the firing pin is driven into the primer immediately upon the first contact of the missile; functions at the surfaces of the target. Also called instantaneous fuse.

Supersensitive Fuse that will set off a projectile when it strikes even a very light target, such as an airplane wing.

Supersonic Greater than the speed of sound, over Mach 1.

Supplemental Charge Filler, normally TNT, used in deep cavitied projectiles to fill void between ordinary fuse and booster combination and bursting charge.

Sure-Fire Current Minimum current which must be applied to a bridge-wire circuit to reliably ignite the prime material without regard to the time of operation.

Surface tension the cohesion forces (Adhesion and Cohesion) at the surface of a liquid. The molecules within a liquid are attracted equally from all sides, but those near the surface experience unequal attractions and thus are drawn toward the centre of the liquid mass by this net force. A result of surface tension is the tendency of a liquid to reduce its exposed surface to the smallest possible area.

Surfactant a surface-active substance, such as a detergent or soap, that lowers the surface tension of a solvent (usually water).

Surveillance (as it pertains to ordnance) Observation, inspection, investigation, test study and classification of ammunition, ammunition components and explosives in movement, storage and use with respect to degree of serviceability and rate of deterioration.

Sustainer Grain A propellant or pyrotechnic grain used in a pressure cartridge or igniter to sustain burning.

Swell Diameter Maximum diameter of the ogive extended to the place where its generating arc is parallel to the centre line.

Switch An electrical device having two states-on, or closed, and off, or open-and, ideally, having the property that when closed it offers a zero Impedance to a current and when open it offers infinite impedance to a current. For many operations, as in digital computers, the operation of mechanical switches, which move contacts together and apart, is too slow. When faster switching is required, Transistors or vacuum tubes are used, operated in such a way that they conduct either heavily or very little.

Sympathetic Detonation (Ignition) The explosion of a second charge or device caused by nearby detonation (ignition) of another.

Sympathetic Propagation The detonation of an explosive material as the result of receiving an impulse from another detonation through air, earth, or water.

Synthetic Elements radioactive chemical elements discovered not in nature but as artificially produced isotopes. They are TECHNETIUM, PROMETHIUM, ASTATINE, FRANCIUM, and the TRANSURANIUM ELEMENTS. Some have since been found to exist in small amounts in nature as short-lived members of natural radioactive decay series.

Systems of Crystals The seven large divisions into which all crystallizing substances can be placed; cubic, tetragonal, hexagonal, trigonal, orthorhombic, monoclinic, triclinic. This classification is based on the degree of symmetry displayed by the crystals.

T

Tail effect Usually a term applied to a shell in which a star (comet) has been attached to the outside and which produces a rising column of sparks on the shell's ascent. "Tail" may also be applied to rockets, Roman candle stars or even whistle units where a persistent (usually silver) spark follows the flight of the device.

Talc A monoclinic hydrated magnesium silicate, [MgSi8O20(OH)4].

Taliani Test A heat stability test for propellants and explosives.

Tamping Pole A wooden or plastic pole used to compact explosive charges or stemming.

Tamping The act of charging or tamping a charge into a hole, with the aid of a tamping stick. Sometimes used loosely for the term "stemming". The action of compacting the explosive charge or the stemming in a blasthole.

Tar (and pitch) viscous, dark-brown to black substances, obtained by the destructive distillation of certain organic materials, e.g., Coal, Wood, and Petroleum. Although the terms tar and pitch are sometimes used interchangeably, pitch is actually a component of tar that can be isolated by heating. Tar, more or less fluid, is now used to produce Benzene and various other substances. Tar from pine wood is used to make soap and medicines. Coal tar derivatives are used to make dyes, cosmetics, and synthetic flavouring extracts. Pitch tends to be more solid than tar and is used to make roofing paper, in varnishes, as a coal-dust binder in making fuel briquettes, and as a lubricant. Asphalt is a naturally occurring pitch.

Target Area An area to be entered or breached, generally where a threat resides.

Tarnish The discolouration produced on the surface of an exposed metal or mineral, generally as a result of the formation of an oxide or a sulphide film.

Tear Gas Volatile compounds which even in low concentrations make vision near impossible due to their irritating action chiefly on the eyes. They are halogenated organic compounds, xylyl bromide CH3C6H4CH2Br and ethyl iodoacetate CH2ICOOC2H5. Nowadays pyrotechnic devices contain CS as the irritant.

Temperature Coefficient The relative change of a property (pressure, burning time) with the temperature.

Temperature the measure of the relative warmth or coolness of an object. The temperature of a substance measures not its heat content but rather the average kinetic energy of its molecules. Temperature is measured by means of a Thermometer or other instrument having a scale calibrated in units called degrees. A temperature scale, is determined, by choosing two reference temperatures and dividing the temperature difference, between these points into a certain number of degrees. The size of the degree depends on the particular temperature scale being used. The most common reference temperatures are the Melting Point of ice and the Boiling Point of water. An absolute temperature scale for which zero degree corresponds to zero average kinetic energy can be defined theoretically (Kinetic-Molecular Theory of Gases); the Kelvin temperature scale is an absolute scale having degrees the same size as those on the Celsius scale.

Terminal Velocity The constant velocity of a falling body attained when the resistance of air or other ambient fluid has become equal to the force of gravity acting upon the body. Sometimes called "limiting velocity."

Tetryl Sensitive explosive used especially in caps and boosters to detonate less sensitive explosives, and as the explosive filler in some types of projectiles.

Thermal stability The tendency for a composition to ignite from the energy applied by heat. Thermal stability testing is routinely carried out as part of the authorisation procedure for fireworks in many countries.

Thermistor a semiconductor whose resistance will vary with temperature.

Thermite A high temperature producing mixture. Typical mix contains aluminium and iron oxide (FE3O4) and is still used for in situ welding of railway tracks.

Thermocouple a temperature-measuring device formed by joining the ends of two strips of dissimilar metals in a closed loop, with the two junctions at different temperatures. Because the voltage that arises in this circuit is proportional to the temperature difference between the junctions, the temperature at one junction can be determined if the other junction is maintained at a known temperature.

Thermodynamics The science of the mechanical action of heat, or the relationship of heat and mechanical energy, and the conversion of one into the other. Refers to the branch of science concerned with the nature of heat and its conversion into other forms of energy. Heat is a form of energy associated with the positions and motion of the molecules of a body (Kinetic-Molecular Theory of Gases). The total energy that a body contains as a result of the positions and the motions of its molecules is called its internal energy. The first law of thermodynamics states that in any process the change in a system's internal energy is equal to the heat absorbed from the environment minus the work done on the environment. This law is a general form of the law of conservation of energy (Conservation Laws). The second law of thermodynamics states that in a system the entropy cannot decrease for any spontaneous process. A consequence of this law is that an engine can deliver work only when heat is transferred from a hot reservoir to a cold reservoir or heat sink. The third law of thermodynamics states that all bodies at absolute zero would have the same entropy; this state is defined as having zero entropy.

Thermometer an instrument for measuring temperature. A clinical thermometer consists of a small vacuum tube of uniform bore, with a temperature scale etched on its front. The tube is closed at one end and connected at the other with a chamber containing mercury or another liquid. When the chamber is heated, the fluid expands and rises into the tube.

Thrust The resultant force in the direction of motion produced by a rocket motor.

Thruster The thruster was designed to provide a force through a relatively short stroke. The device consists of a cylinder, piston and propellant cartridge.

Thunderflash A generic term for a report with flash.

Thunderstorm A violent local atmospheric disturbance accompanied by lightning, thunder, and heavy rain, often by strong gusts of winds and sometimes by hail. The typical thunderstorm caused by convection occurs on a hot summer afternoon when the sun's warmth has heated a large body of moist air near the ground. This air rises and is cooled by expansion. The cooling condenses the water vapour in the air, forming a cumulus cloud. If the process continues violently, the cloud becomes immense; the summit often attains a height of 4 mi (6.5 km) above the base, and the top spreads out in the shape of an anvil as the transition to a cumulonimbus cloud occurs. The turbulent air currents within the cloud cause a continual breaking up and reuniting of the raindrops, building up strong electrical charges that result in lightning.

Tiger tail shell Usually a solid sphere of composition fired in exactly the same manner as a shell. The effect produced is of an extremely thick rising comet. Optionally there is a small shell burst at the apex of its flight.

Titanium [Ti] A silver metal much used for producing brilliant white sparks (e.g in a maroon or gerb). Titanium does not corrode but is extremely hard and may increase the friction sensitivity of a firework composition. Very hot sparks are produced from this metal.

Titanium Dioxide, titanium (iv) oxide, rutile. **[TiO2]** White powder used as a catalyst in whistle rockets.

Titanium, flakes [Ti/Vn/Al] Aerospace alloy: 90% titanium, 6% vanadium, 4% aluminium. Slightly brighter white sparks than the pure stuff. Works well in salutes, fountains, gerbes, and comets.

Titanium sponge, [Ti] Bright white sparks. An excellent form of the metal which works well in maroons, fountains, gerbes, and comet stars.

Titration a method of analysing the composition of a solution by adding known amounts of a standardized solution until a given reaction (colour change, precipitation, or conductivity change) is produced.

Titration The determination of the concentration of acids or bases (Acids and Bases) in solution by the gradual addition of an acidic solution of known volume and concentration to a basic solution of known volume, or vice versa, until complete neutralization (observable by the colour change in an added indicator, such as phenolphthalein) has occurred.

TNT equivalent A measure of explosive strength used as a comparison to TNT, usually for determining safe loading of buildings.

TNT Trinitrotoluene.

Top fused Usually an aerial shell in which the time fuse (shell delay) for the functioning of the bursting charge is physically at the tope of the shell and lit independently to the lifting charge.

Torbillion Also Tourbillion. Either very similar to a serpent unit, or a lager aerial firework comprised of a saxon and wing, designed to rise into the air on ignition.

Torch *see flare* Also hand held electric source of light used checking all operations at night on displays. Only light source the public showed used for checking any firework firing instructions details

Torpedo - Fwk. A flying squib or throwdown.

Torpedo - Mil. A missile designed to contain an explosive charge and be launched into water where it is self-propelling and usually direction able.

Tracer Element of a type of ammunition (called tracer ammunition) containing a chemical composition, which burns visibly in flight. Tracer is used for observation and adjustment of fire, for incendiary purposes, and for signalling.

Trajectory Chart Diagram of a side view of the paths of projectiles fired at various elevations, under standard conditions. The trajectory chart varies for different guns, projectiles and fuses.

Trajectory Path of projectile, missile or bomb in flight.

Transducer A device which changes one form of energy into another. A loudspeaker changes electrical energy into acoustical energy, for example. A transducer is a device that accepts an input of energy in one form and produces an output of energy in some other form, with a known, fixed relationship between the input and output. One class of transducers consists of devices that produce an electrical output signal, e.g., Microphones, Record-Player cartridges, and Photoelectric Cells. Other transducers accept an electrical input, e.g., Loudspeakers, light bulbs, and Solenoids. Transducers may be either active or passive. Active transducers require a source of energy in addition to the input signal to produce the output signal, whereas passive transducers require only an input signal.

Transformer an electrical device that transfers an alternating current or voltage (Potential, Electric) from one Electric Circuit to another using Electromagnetic Induction. A simple transformer consists of two coils of wire electrically insulated from each other and arranged so that a change in the current through the primary coil will produce a change in voltage across the secondary coil. The ratio of the alternating-current (AC) output voltage to the AC input voltage is approximately equal to the ratio of the number of turns in the secondary coil to the number of turns in the primary coil. This capability for transforming voltages is the basis for a great many applications. Transformers are classified according to their use; power transformers (Power, Electric) are used to transmit power at a constant frequency, audio transformers are designed to operate over a wide range of frequencies with a nearly constant ratio of input to output voltage, and radio-frequency transformers operate efficiently within a narrow range of high frequencies.

Transistor an electronic device used as a voltage and current amplifier, consisting of semiconductor materials that share common physical boundaries. The material most commonly used is silicon into which impurities have been introduced. In n-type semiconductors there is an excess of free electrons, or negative charges, whereas in p-type semiconductors there is a deficiency of electrons and therefore an excess of positive charges. Transistors are used in many applications, including radio receivers, electronic computers, and automatic control instrumentation (e.g., in spaceflight and guided missiles). Since the invention (announced in 1948) of the transistor by the American physicists John Bardeen, Walter H. Brattain, and William Shockley, many types have been designed. The n-p-n junction transistor consists of two n-type semiconductors separated by a thin layer of p-type semiconductor; the three segments are called emitter, base, and collector, respectively, and are usually sealed in glass, with a wire extending from each segment to the outside, where it is connected to an electric circuit. The transistor action is such that if the electric potentials on the segments are properly determined, a small current between the emitter and base connections results in a large current between the emitter and collector connections, thus producing current and amplification. The p-n-p junction transistor, consisting of a thin layer of n-type semiconductor lying between two p-type semiconductors, works in the same manner, except that all polarities are reversed.

Transition Elements or Transition Metals Elements of group VIII and the b groups (I through VII) of the Periodic Table, characterized by the filling of an inner d or f electron orbital as atomic number increases. Many chemical and physical properties of these elements are due to their unfilled d or f orbitals. Transition elements generally have high densities and melting points, magnetic properties, and variable valence arising from the electrons in the d or f orbitals. These metals form stable coordination complexes, or complexions, many of which are highly colored and exhibit paramagnetism.

Transponder An electronic device that receives a challenging signal and automatically transmits a response.

Transportation The process of consigning a load of fireworks, usually taken to apply once the consignment has left the factory gates. Transportation of fireworks is subject to heavy legislative control.

Transtainer A low trailer for transportation of the rocket stages.

Transuranium Elements Radioactive chemical elements with atomic numbers greater than 92 (Uranium). Only Neptunium (at. no. 93) and Plutonium (at. no. 94) occur in nature; they are produced in minute amounts in the radioactive decay of uranium. The transuranium elements of the Actinide Series were discovered as synthetic radioactive isotopes. Both American and Soviet scientists claim to have discovered independently the unstable transactinide elements 104, 105, and 106, and West German scientists reported discovering the unstable transactinide elements 107 and 109.

Trauzl Test Method of determining relative energy available from an explosive material by measurement of the volume expansion of a lead block test.

Trigonometry The study of certain mathematical relations originally defined in terms of the angles and sides of a right triangle, i.e., one containing a right ANGLE (90Ý). Six basic relations, or trigonometric functions, are defined. If A, B, and C are the angles of a right triangle (C = 90Ý) and a, b, and c are the lengths of the respective sides opposite these angles, then six functions can be expressed for one of the acute angles, say A, as various ratios of the opposite side (a), the adjacent side (b), and the hypotenuse Ş, as set out in the table. Although the actual lengths of the sides of a right triangle may have any values, the ratios of the lengths will be the same for all similar right triangles, large or small. It may be seen that sin B = cos A, cos B = sin A, tan B = cot A, and so forth. The values of the sine and the cosine are always between 0 and 1, the values of the secant and the cosecant are always equal to or greater than 1, and the values of the tangent and the cotangent are unbounded, increasing from 0 without limit. The values of the trigonometric functions can be found in a set of tables or on a calculator. The notion of the trigonometric functions is extended beyond 90Ý (the largest angle size in a right triangle) by defining the functions with respect to Cartesian Coordinates; the functions then take on negative as well as positive values in a pattern that repeats every 360Ý. This repeating, or periodic, nature of the trigonometric functions leads to important applications in the study of such periodic phenomena as light and electricity. A general triangle, not necessarily containing a right angle, can also be analyzed by means of trigonometry. Spherical trigonometry, the study of triangles on the surface of a sphere, is important in surveying, navigation, and astronomy.

Trimonite High explosive used as a substitute for trinitrotoluene as a bursting charge. Trimonite is a mixture of picric acid and mononitronaphthalene.

Trinitrophenol Picric Acid.

Trinitrotoluene (TNT) High explosive widely used as explosive filler in projectiles and by engineers.

Trinitrotoluol Trinitrotoluene.

Triple Point Intersection of the original shock wave, the reflected shock wave and the Maeh stem.

Triple-Base Propellant whose principal active ingredients are nitrocellulose, nitroglycerin and nitroguanidine.

Trunk The rising comet star effect seen on palm shells, and various other shells.

Trunkline The line of detonating cord on the ground surface that connects detonating cord downlines.

Tube The inner cylinder of a built-up gun, usually extending from the inner face of the breechblock to the muzzle.

Tubular Grain A solid propellant grain in the form of a tube.

Tungsten [W] Clumpy material that can easily be milled and/or screened to fine powder. Flammable, but not used to a great extent in fireworks.

Twist Inclination of the spiral grooves to the axis of the bore of a weapon. The degree of twist is the determining factor in the speed of rotation of the projectile.

U

Ullage The empty volume of a propellant tank which is not occupied by fuel or oxidizer.

Ultramarine. (sodium disilicate). **[Na3S2.3NaAlSiO4]** Fine blue powder used to produce yellow flames. Unlike other sodium-based yellow flame producers, ultramarine stores well. Shimizu says it can be used with ammonium perchlorate.

Ultrasonics is the study and application of Sound Waves with frequencies greater than 20,000 cycles per second, i.e., beyond the range of human hearing. Ultrasounds are commonly produced by piezoelectric transducers. They are used for non-destructive testing, and for the cleaning of fine machine parts and surgical instruments. In medicine, Ultrasound devices are used to examine internal organs without surgery. Ultrasonic whistles are audible to dogs and are used to summon them.

Ultrasound in medicine, a technique that uses sound waves to study hard-to-reach body areas. In scanning with ultrasound, high-frequency sound waves are transmitted to the area of interest and the returning echoes recorded. First developed in World War II to locate submerged objects, the technique is now widely used in virtually every branch of medicine, e.g., in obstetrics to study the foetus, in cardiology to detect heart damage, in ophthalmology to detect retinal problems. It is noninvasive, involves no radiation, and avoids the possible hazards-such as bleeding, infection, or reactions to chemicals-of other diagnostic methods.

Ultraviolet Radiation is invisible Electromagnetic Radiation with frequencies (about 1015 to 1018 Hz) between that of visible violet light and X rays; it ranges in wavelength from about 400 to 4 nanometers. Ultraviolet (UV) radiation can be detected by the Fluorescence it induces in certain substances and by its blackening of photographic film. Most of the UV component of sunlight is absorbed by the Ozone layer of the atmosphere. UV radiation can also be produced artificially in arc lamps. Vitamin D in humans is produced by the action of UV radiation on ergosterol, a substance present in the human skin.

UN classification The assignment of a packaged firework into one of the UN's 5 classes for fireworks

UN compatibility group The "G" of 1.3G. The compatibility group, largely irrelevant for most firework usage, prescribes which explosives may be transported with which others. For instance detonators should not be transported with primary explosives, explosives containing toxic agents should not be transported AT ALL!

UN hazard code *See UN number*

UN mark A complicated index assigned to the PACKAGING of a dangerous good. (*See UN number*)

UN number A four digit number assigned to any hazardous goods after classification in its TRANSPORT PACKAGING according the methods prescribed in the "orange book". For fireworks the relevant numbers are 0333 (1.1G), 0334 (1.2G), 0335 (1.3G), 0336 (1.4G) and 0337 (1.4S). The UN number should always be quoted as it uniquely identifies an item AND its hazard.

Unconfined Detonation Velocity The detonation velocity of an explosive material without confinement, for example, a charge fired in the open.

Unsaturated any chemical compound with more than one bond between adjacent atoms, usually carbon, and thus reactive toward the addition of other atoms at that point; or example, olefins, diolefins, and unsaturated fatty acids.

Uranium [U] radioactive metallic element, discovered in oxide form in Pitchblende by M.H. Klaproth in 1789. A silver-white, hard, dense, malleable, ductile, highly reactive metal in the Actinide series it occurs naturally as a mixture of three Isotopes. Because of a constant decay rate, the age of uranium samples can be estimated (Dating). The rare uranium-235 isotope is the only naturally occurring fission fuel for Nuclear Energy. Breeder reactors convert the abundant but nonfissionable uranium-238 into fissionable plutonium-239. Uranium-235 and plutonium-239 are also practicable fissionable nuclei for Atomic Bombs.

V

Valence or oxidation state, combining capacity of an Atom expressed as the number of single bonds the atom can form or the number of electrons an Element gives up or accepts when reacting to form a compound. The valence of an atom is determined by the number of electrons in the outermost, or valence, electron shell. An atom exists in its most stable configuration when its outermost shell is completely filled; in combining with other atoms, it thus tends to gain or lose valence electrons in order to attain a stable configuration. The valence of many elements is determined from their ability to combine with hydrogen or to replace it in compounds.

Vector A quantity having both magnitude and direction. Many physical quantities are vectors, e.g., force, velocity, and momentum. The simplest representation of a vector is an arrow connecting two points: [m.ABvector] designates the vector represented by an arrow from point A to point B, whereas [m.BAvector] designates the vector of equal magnitude from B to A. In order to compare vectors and to operate on them mathematically, it is necessary to have some reference system that determines scale and direction, such as Cartesian Coordinates. A vector is frequently symbolized by its components with respect to the coordinate axes. Suppose, for example, that the point A has coordinates (2,3) and the point B has coordinates (5,7). The x-component of [m.ABvector] i.e., its size with respect to the x-axis, is the difference between the x-coordinates of the points A and B, or 5 - 2 = 3; the y-component is 7 - 3 = 4. Thus [m.ABvector] becomes {3,4}. Knowledge of the components of a vector enables one to compute its magnitude-in this case, 5, by the Pythagorean theorem {(32 + 42)1/2 = 5}-and its direction (from Trigonometry). There are an infinite number of vectors with the components {3,4}, all of which have the same magnitude and direction; they are considered equal. The concept of a vector can be extended to three or more dimensions. To add two vectors U and V, one can add their corresponding components to find the resultant vector R, or one can graph U and V on a set of coordinate axes and complete the parallelogram formed with U and V as adjacent sides to obtain R as the diagonal from the common vertex of U and V. The scalar, or dot, product of two vectors A and B is a nondirectional (scalar) quantity with a magnitude of A+B = |A| |B| cos ;gu, where ;gu is the angle between A and B. The vector, or cross, product of A and B is a vector whose magnitude A + B = |A| |B| sin ;gu and whose direction is perpendicular to both A and B and pointing in the direction in which a right-hand screw would advance if turned from A to B through the angle.

Velocity 1) Speed. 2) A vector quantity equal to speed in a given direction.

Venturi Tube A short tube with varying cross sections and a constricted throat which controls flow velocity

Very Pistol A firing device for pyrotechnical cartridges.

Vinsol Resin. Dark brown powder. A pine-derived synthetic resin used as a binder. Solvents are alcohol, ketones

Visco fuse A fuse, commonly used on consumer fireworks as the delay fuse, which is usually made by wrapping a core of blackpowder with thread and lacquer.

Viscosity And Consistency Related but different rheological (pertaining to flow) terms.

Viscosity resistance of a fluid to flow. This resistance acts against the motion of any solid object through the fluid, and also against motion of the fluid itself past stationary obstacles. Viscosity also acts internally on the fluid between slower and faster-moving adjacent layers. All fluids exhibit viscosity to some degree.

VOD Velocity of detonation, a measure of the rate at which the detonating wave travels through an explosive charge; the speed of detonation of a particular explosive. Detonating Velocity.

Volley A term usually applied to a mass firing or rockets.

Volt The unit of voltage or, more technically, of Electric Potential and Electromotive Force. It is defined as the difference of electric potential existing across the ends of a conductor having a resistance of 1 OHM when the conductor is carrying a current of 1 AMPERE.

Voltage the electrical pressure (electromotive force) that makes current flow through a conductor.

Volume the space occupied in three dimensions.

W

Warhead The explosive portion of a rocket, guided missile or torpedo containing the destructive load which the vehicle is to deliver.

Warning Signal A visual or audible signal that is used for warning personnel in the vicinity of the blast area of the impending explosion.

Warimono shell A Japanese term for the type of shell that produces a spherical burst of stars.

Water firework The generic term for any firework fired on the surface of water to maximise the visual effect of its reflections.

Water Gel An explosive material containing substantial portions of water, oxidizers, and fuel, plus a cross-linking agent.

Water gerb Usually a gerb or fountain weighted at one end and attached to a piece of cork designed to function on the surface of water. A water gerb may be lit by hand and thrown onto the water's surface, or fired like a shell from a mortar (in each case with a suitable delay fuse).

Water [H2O] odourless, tasteless, transparent liquid that is colourless in small amounts but exhibits a bluish tinge in large quantities. It is the most abundant liquid on earth. In solid form (ice) and liquid form it covers about 70% of the earth's surface. Chemically, water is a compound of hydrogen and oxygen whose formula is H2O. The two H-O bonds form an angle of about 105Ý-an arrangement that results in a polar molecule, because there is a net negative charge toward the oxygen end (the apex) of the V-shaped molecule and a net positive charge at the hydrogen ends. Consequently, each oxygen atom is able to attract two nearby hydrogen atoms of two other water molecules. These hydrogen bondings keep water liquid at ordinary temperatures. Because water is a polar compound, it is a good solvent. Because of the hydrogen bondings between molecules, the latent heats of fusion and of evaporation and the Heat Capacity of water are all unusually high. For these reasons water serves both as a heat-transfer medium (e.g., ice for cooling and steam for heating) and as a temperature regulator (the water in lakes and oceans helps regulate the climate). Water is chemically active, reacting with certain metals and metal oxides to form bases, and with certain oxides of non-metals to form acids. Although completely pure water is a poor conductor of electricity, it is a much better conductor than most pure liquids because of its self-ionization, i.e., the ability of two water molecules to react to form a hydroxyl ion (OH-) and a hydronium ion (H3O+).

Water shell A shell designed to function on the surface of water (e.g a lake) producing a hemisphere of stars. Water shells may be fired from mortars angled at a low angle, or may be set up on the water's surface prior to the star to the display.

Waterfall Usually an extended curtain of silver sparks form vertical or horizontally burning tubes filled with a composition containing aluminium. Waterfall shells produce the same effect and are best fired en masse to produce a spectacle.

Waterglass. *See sodium silicate*

Watt A unit of electrical power equal to 1 joule/sec.

Wave in physics, the transfer of Energy by some form of regular vibration, or oscillatory motion, either of some material medium (Sound) or by the variation of intensity of the field vectors of an electromagnetic field (Electromagnetic Radiation). In longitudinal, or

compressional, waves the vibration is in the same direction as the transfer of energy; in transverse waves the vibration is at right angles to the transfer of energy. The amplitude of a wave is its maximum displacement. The distance between successive crests or successive troughs is the wavelength l of a wave. One full wavelength of a wave represents one complete cycle, that is, one complete vibration in each direction. All waves are referenced to an imaginary synchronous motion in a circle; thus one complete cycle is divided into 360 degrees. The phase is that part of the cycle, expressed in degrees, that is completed at a certain time. The various phase relationships between combining waves determine the type of interference that takes place. The frequency n of a wave is equal to the number of crests (or troughs) that pass a given fixed point per unit of time. The period T of a wave is the time lapse between the passage of successive crests (or troughs). The speed v of a wave is determined by its wavelength and its frequency according to the equation v = ln. Because the frequency is inversely related to the period T, this equation also takes the form v = l/T.

Wavefront Surface which is the locus of all molecules having motion in identical phase in a propagating wave.

Weather-Resistant Construction designed to offer reasonable protection against weather.

Web, Web Size, Web Thickness 1) Alternate terms describing the minimum distance between any two specified burning surfaces of a propellant grain. 2) Terms used in describing portions of structural "I" beams and "H" beams.

Web Range Tolerance of web thickness to allow for manufacturing limitation.

Weight Strength The energy of an explosive material per unit of weight expressed as a percentage of the energy per unit of weight of a specified explosive standard.

Weight The force with which an earth-bound body is attracted toward the earth. Weight, a measure, commonly expressed in pounds or grams, of the force of gravity on a body (Gravitation), which is more correctly measured in newtons. Because the weights of different bodies at the same location are proportional to their masses, weight is often used as a measure of Mass. Unlike the mass, the weight of a body depends on its location in the gravitational field of the earth or of some other astronomical body.

Weights And Measures units and standards for expressing the amount of some quantity, such as length, capacity, or weight; the science of measurement standards and methods is known as metrology. Crude systems of weights and measures probably date from prehistoric times. Early units were commonly based on body measurements and on plant seeds or other agricultural objects. As civilization progressed, technological and commercial requirements led to increased standardization. Units were usually fixed by edict of local or national rulers and were subdivided and multiplied or otherwise arranged into systems of measurement. Today the chief systems are the English Units Of Measurement and the Metric System. The United States is one of the few countries still using the former system.

Wheel A rotating set piece, usually powered by gerbs or turning cases, and most often rotating in a vertical plane.

Whistle Usually a tube containing a composition made using potassium benzoate, potassium salicylate, or rarely nowadays, potassium picrate. On burning the composition burs in a rapidly oscillating manner, and the resulting pressure waves are amplified by the tube in a manner similar to an organ pipe.

White Phosphorous Yellow waxy solid which ignites spontaneously when exposed to air. It is used as a filling for various projectiles as a smoke-producing agent and has an incendiary effect. White phosphorous may be mixed with a xylene solution of synthetic rubber to form plasticised white phosphorous.

Whizzer American term for firework hummer

Willow shell An extremely attractive shell comprising stars made with a high percentage of charcoal. the effect is of long-burning golden stars which often (but undesirably) fall all the way to the ground.

Window A type of confusion reflector consisting essentially of metal foil ribbon, but sometimes metalized on one side only. Also known as "chaff."

Wire Gauge wire size, measured in diameter.

Wood Meal Extremely fine flour, much finer than sawdust. Light tan powder used as a filler and thickener for glue, occasionally as a fuel in lance and flash compositions.

Work in physics, transfer of Energy by a force acting against a resistance or a body and resulting in displacement. Work W has a magnitude equal to the scalar product (Vector) of the force F and the distance d of the resulting movement; thus W = Fd cos ;gu, where;gu is the angle between the directions of the force and the movement. The foot-pound English Units of Measurement), the erg (cgs system), and the joule (mks system) are the units of work or energy expended, respectively, by a 1-lb force acting through a distance of 1 ft, by a 1-dyne force through 1 cm, and by a 1-newton force through 1 m. One foot-pound equals 1.356 joules; 1 erg equals 10-7 joules.

X

Xenon [Xe] gaseous element, discovered spectroscopically in 1898 by William Ramsay and M.W. Travers. It is a rare, colourless, odourless, tasteless Inert Gas used in certain photographic-flash lamps, in high-intensity arc lamps for motion-picture projection, in high-pressure arc lamps to produce ultraviolet light, and in numerous radiation-detection instruments.

X-Ray Electromagnetic radiation of very short wavelength, lying within the wavelength interval of 0.0 to 100 angstroms (between gamma rays and ultra-violate radiation). Also called "X-radiation", "Roentgen ray." (X-rays penetrate various thicknesses of all solids and they act upon photographic plates in the same manner as light. Secondary X-rays are produced whenever X-rays are absorbed by a substance; in the case of absorption by a gas, this results in ionization.)

Xylene [C8H10] Clear liquid. Solvent for parlon, saran, etc. Also used as a solvent-bond for plastic shell case halves.

Y

Yaw

l) The lateral rotational or oscillatory movement of an aircraft, rocket or the like about a transverse axis.

2) The amount of this movement, i.e., the angle of yaw.

Z

Zero G Weightlessness.

Zinc Chromate (chromium zinc oxide, zinc tetraoxychromate). **[ZnCrO4]** Bright yellow powder used as rocket fuel catalyst.

Zinc Oxide [ZnO] White powder used in smoke compositions and as a pyro-adhesive.

Zinc Powder [Zn] Grey powder. Grey metal used in fireworks to make spreader stars, smoke and in rockets to make a low specific impulse propellant.

Zinc Stearate [Zn(C18H35O2)2] White powder, with a greasy feel. Used to aid pressing of smoke compositions, slighty increases the burning rate.

Zirconium [Zr] Incredibly bright white sparks. Excellent for ignitors.